SER. II, VOL. 12 *January, 1950* No. 3

TRANSACTIONS
OF
THE NEW YORK ACADEMY OF SCIENCES

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TRANSACTIONS of The New York Academy of Sciences, Series II, Volume 12, No. 3, January, 1950. Entered as second-class matter December 12, 1947, at the post office at Baltimore, Maryland, under the act of August 24, 1912. This publication is distributed to members and is published monthly from November to June, inclusive, by The New York Academy of Sciences, Mt. Royal and Guilford Aves., Baltimore 2, Md. Editorial office: Seventy-Ninth Street and Central Park West, New York 24, N. Y.

Executive Director: EUNICE THOMAS MINER

*SECTION OF GEOLOGY AND MINERALOGY**

PERMIAN FAUNAS OF THE GLASS MOUNTAINS, TEXAS, AND THEIR ENVIRONMENT

By G. ARTHUR COOPER†

The fossils which form the subject of this paper were prepared in the paleontological laboratory of the U. S. National Museum by etching blocks of Permian limestone taken from several formations in the Glass Mountains, west Texas. The Glass Mountains are located north of the village of Marathon. They extend in a northeast-southwest direction for 40 miles and straddle the Brewster-Pecos county line. The mountains are almost wholly composed of Permian limestones, and a nearly complete sequence is exposed.

The fossils come from only the lower three formations: Wolfcamp, Leonard, and Word. The formations above these are mostly dolomites or without silicified fossils. The Wolfcamp formation, 700 feet thick, consists mainly of shale, with thin or thick limestone lenses, the latter containing the bizarre fauna that has made the formation famous. The Leonard formation is about 2000 feet thick and is composed of two contrasting facies separated by reef limestones. The eastern facies is composed of fusulinid-bearing, thin-bedded limestones, while the western facies is composed of silicious limestones and shales. The upper 300 feet contain reefy deposits and abound in fossils. The Word formation is a great wedge, about 1500 feet thick, of silicious shales and thin limestones thinning to the northeast to 500 feet of cherty limestone. Four thick limestones which contain numerous fossils occur in the shaly mass on the thick side of the wedge.

All evidence points toward the fact that the environment of the Glass Mountains formations just noted was deposited in a near-shore zone. This fact can also be detected in the type of fossils and the sediments. Most of the limestones are very sandy and some contain quartz pebbles over an inch in diameter. Many of the fossils are thick-shelled brachiopods that formed clusters and small reefs in turbulent water.

The Permian fauna of the Glass Mountains abounds in all types of invertebrate animals. The fossils thus far brought together are the result of dissolving approximately 17 tons of limestone in dilute hydrochloric acid. This type of preparation of silicified fossils is a well-known and time-honored method of preparing specimens, but, at the National Museum, a new note was added to the familiar methods. The novelty is large scale. Blocks up to 200 pounds are processed and it is from these big lumps that the finest and largest specimens are obtained. The yield consists of many types of sponges, numerous small corals (few large and colonial corals are yet known from the Texas Permian), exquisite small crinoids, numerous molluscs (including spiny cephalopods), and a few trilobites. Of all the fossils obtained, the brachiopods are the most numerous and in greatest variety. They are of especial interest because of the high specialization obtained by some of them.

Most of the brachiopod superfamilies are present in the Glass Mountains fauna. The usual and familiar rhynchonellids, terebratulids, and spiriferids of the upper Paleozoic are abundant, but the most remarkable groups are the Orthotetinae, Leptodinae, and Productacea. Of the former groups, large *Derbyias* are common. Some are broad and flat, whereas others have long attenuated beaks. A variety of *Meekella* is common, and streptorhynchids of bizarre form are present. Of especial interest is the genus *Scacchinella*, which attains a length of over six inches and is one of the largest known brachiopods. This peculiar

* This paper, illustrated with lantern slides, was presented at the meeting of the Section, December 5, 1949.

† United States National Museum, Washington, D. C.

shell is suggestive of the rudistid pelecypods of the Cretaceous seas. The brachial valve is a lid to a deep conical valve. This genus has a huge forked cardinal process and the conical pedicle valve is filled with blister-like cysts. It lived in large clusters, with the valves closely cemented together.

Perhaps the most peculiar and most specialized brachiopod is *Leptodus*. This animal had an ostreiform shell, usually cemented in small clusters by the beak. The inner surface of the pedicle or attached valve has a median shallow groove from which extend lateral grooves nearly to the lateral margins. The brachial valve consists of a central axis and a series of unconnected ladder-like lobes on each side. The central axis of the brachial valve fits over the central groove, and the lateral lobes fit snugly into the lateral grooves of the pedicle valve. The shell is thus essentially a sieve, and the animal feeds by taking in food-bearing water currents in the spaces between the lateral lobes.

The Productacea is composed of several families of very spiny brachiopods. The spines have often been the subject of some speculation as to how they served the animal. Evidence from the Glass Mountains specimens shows that some of the productids were attached throughout life by their spines, others were attached during a short youthful stage but then broke off their attachment to live loose on the sea-bottom, and a third group was prevented from burial in the mud by its spines.

Two examples of permanently attached brachiopods may be mentioned. *Aulosteges* lived upright on some hard surface, with the anterior margin free but the posterior cemented down by a great brush of spines located along the posterior margin and on the ears. *Prorichthofenia* is another attached brachiopod which took the form of a cup-coral. The pedicle valve is conical, while the brachial valve is a lid-like operculum located below the mouth of the cup. The animal is cemented by long spines and the tip of the brachial valve to some solid object. In upper Leonard time it made clusters and small reefs on the sea floor.

Institella is a productid that was attached in young stages but broke free in later life. It often attached to crinoid stems but, as it grew, great spines extended posteriorly from the cardinal extremities for approximately two and one-half inches. In its adult form, it must have lain on its pedicle valve with the long cardinal spines stretched out and preventing it from being tipped over by currents. Another brachipod attached itself to seaweed or other small cylindrical objects by two spines that made a ring of attachment. After the shell became an adult and lived loose on the bottom, it was provided with a brush of long spines on each ear and long spines that curved over the anterior shell margin. No matter how the specimen came to rest on the sea bottom, its spines protected the front margin from being buried. It is believed the shell was moved about like a tumbleweed and may have been drifted with others into spongy masses of productids.

Shells that lived loose on the bottom, such as *Krotovia*, were provided with enormous cardinal spines. Another shell, *Yakovlevia*, had only four spines, two at the cardinal extremities and two extending horizontally from the place of geniculation of the front margin. The spines often attained a length of more than two inches and thus served to steady the shell on the mud as it lay convex side down.

All of these highly specialized creatures disappeared at the end of the Permian. They must have been a prey to their own unchangeability in the oscillating conditions of Permian time.

*SECTION OF PHYSICS AND CHEMISTRY**

STABILITY STUDIES OF STRUCTURAL FRAMES†

By ABRAHAM SLAVIN‡

Synopsis. The purpose and scope of this investigation is: To determine, by stability studies of several typical rigid planar trusses of structural steel, the critical values and factors in terms of multiple loading, critical compressive unit stresses, relation of critical compressive unit stresses to yield point, critical values of the effective modulus of elasticity, and the column end restraint coefficients, and these on the basis of several design formulas, several concepts of the effective modulus of elasticity, and several yield point values.

To ascertain if simple and satisfactory approximations to the critical stability of several of the trusses may be obtained by analysis of small groups of the truss members and modifications of these groups rather than the truss as a whole.

Introduction. A number of papers have been written on the stability of plane frameworks. In particular, related column research has received noted attention. Stability analysis has received particular attention in the field of aeronautical engineering for structural frames, designed by ultimate load formulas, which have compression members in the long column range that fail at unit stresses considerably below the yield point. A search of the literature does not reveal a published study of the critical loading of typical, civil engineering, rigid planar trusses nor a comprehensive study of the use of groups of truss members for approximating the critical load of either airplane or civil engineering trusses.

The analyses for the civil engineering trusses of structural carbon steel show the futility of stability computations and indicate the use of the yield point as the practical critical compressive unit stress for these structures designed by working load formulas. For the included airplane and the typical civil engineering trusses, the possibilities of approximating the critical load from simplified assumptions of analysis of small groups of truss members and of the simplest group patterns, for brevity in computations to obtain satisfactory approximations, are indicated.

Theory and Method of Stability Analysis Used. Lundquist[1, 2] used the principles of the Cross[3] method of moment distribution to provide a method for determining the stability of structural members under axial load. The stiffness of the member depends upon the restraint condition at the far end. Three types of restraint are designated as: S, far end fixed; S′, far end elastically restrained; and S″, far end pinned. The stiffness of a member with constant cross section and fixed at the far end, is EI/L and $\frac{1}{4}$ of that by the Cross method. Three designations are used for the carry-over factor: C, far end fixed; C′, far end elastically restrained; and C″, far end pinned. It is assumed that the members lie in the plane of buckling. Two criteria for stability are indicated, the stiffness criterion and the series criterion, either of which may be used. Both the stiffness and the carry-over factor are functions of the axial load in the member. From the moment distribution for the applied unit moment in FIGURE 1, the stiffness criterion for stability is:

$$\Sigma S'bc > 0. \qquad (1)$$

For neutral stability, which gives the critical buckling load for the structure, the stiffness stability factor is set equal to zero, or:

$$\Sigma S'bc = 0. \qquad (2)$$

* This paper, illustrated with lantern slides, was presented at the meeting of the Section, December 6, 1949. It is an abridgment of the paper which was awarded an A. Cressy Morrison Prize in Natural Science in 1949 by the New York Academy of Sciences (*cf.* p. 112).

† An abridgment of the thesis accepted by the faculty of the Graduate Division of the College of Engineering of New York University in partial fulfillment of the requirements for the degree of Doctor of Engineering Science.

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Since there is more than one critical buckling load, the satisfaction of equation (1) is insufficient. The lowest load that satisfies equation (2) is the critical load to be considered.

The series criterion for stability is derived by applying an external unit moment at joint b of the section of a structure, as in FIGURE 2. Far ends of the members are assumed as elastically restrained by coiled springs to allow for the other members beyond the joints at a_1, a_2, a_3, and d_1, d_2, and d_3. In the Cross method, the moment at the end of any member is some quantity times the infinite series $(1 + r + r^2 + r^3$

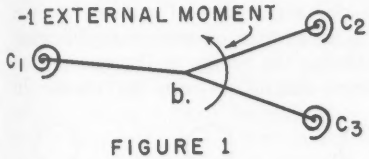


FIGURE 1

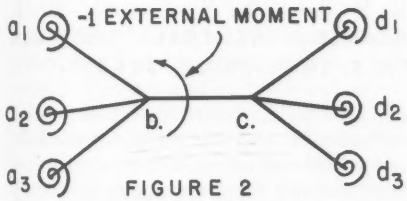


FIGURE 2

$\cdots)$ or $(1/1-r)$. From the moment distribution analysis,[1, 2] the total moment in members ba at joint b, is:

$$\frac{S'ba}{Sbc + \Sigma S'ba} \frac{1}{1 - r} \qquad (3)$$

where

$$r = \frac{Sbc\ Cbc}{Sbc + \Sigma S'ba} \frac{Scb\ Ccb}{Scb + \Sigma S'cd}. \qquad (4)$$

Equation (4) represents the series stability factor or unbalanced moment at joint b. Since the total moment in each member must be finite for stability, the series criterion for stability is:

$$0 < r < 1. \qquad (5)$$

For neutral stability, which gives the critical buckling load of the structure, the series stability factor or unbalanced moment is set equal to unity, or:

$$r = 1. \qquad (6)$$

As noted for the stiffness criterion, the lowest load that satisfies equation (6) is the critical load.

If the carry-over factor is omitted from each part of equation (4), we have the stiffness of the particular member divided by the summation of the stiffness of all the members at the joint, or what is termed $K/\Sigma K$ in moment distribution. This ratio is herein indicated as S_rbc, S_rcd, *etc.*, and called the stiffness ratio. Accordingly, equations (3) and (4) are expressed as:

$$\frac{S_r'ba}{1 - r} \qquad (7)$$

and

$$r = (S_rbc\ Cbc)\ (S_rcb\ Ccb). \qquad (8)$$

For symmetrical conditions, with $S_rbc = S_rcb$, and $Cbc = Ccb$,

$$r = (S_rbc\ Cbc).^2 \qquad (9)$$

Although the method proposed is indicated for analysis of groups of members of a truss for approximations to the critical stability, its use is also applicable to an entire truss.

James[6] combined the formulas originally derived by Muller-Breslau in about 1902 and extended by Niles and Newell[4, 5] with the Cross procedure to allow for beam-column action in rigid frame analysis. With the inclusion of axial load, either tension or compression, in the members of a frame, the moment distribution is modified to the extent that the distribution factors, carry-over factors, and fixed-end moments become functions of L/j instead of being constant for a given number. The L/j value is an abstract number and is computed from the equation of $L/j = L\sqrt{P/EI}$. The moment-distribution coefficients to allow for axial load in compres-

sion or tension, in terms of L/j, are given by Niles and Newell,[5] James,[6] and Lundquist and Kroll.[7, 8]

Hoff[9, 10] developed a method for ascertaining the stability of any system of axial loaded members, applicable to rigid jointed trusses and continuous beam-columns, to which may be applied the Cross method of moment distribution as modified for axial load by James. For simplification in the computations, fixed ends are assumed for joints elastically restrained. For verification of the equivalence of the critical load, where "r" equals unity, the unit moment should be applied separately to each joint at which compression members enter. To satisfy the requirements, "r" must be unique and finite. The moment distribution procedure of Niles and Newell[5] is used.

The design load is notated as Load Factor 1.00, with other load factors corresponding to the respective multiple load values. If the summation of the stiffness of all the members at any joint becomes negative, then the critical load has been exceeded. In the absence of definite criteria to determine the critical load factor of the particular type of structural frame considered, it becomes necessary to evaluate "r" for a series of load factors. Curves of "r" versus load factor are plotted for each joint investigated. The first crossing of such curves with the line of "r" = 1.00 indicates the critical load factor, although above and below the critical load factor the curves may not coincide, due to the varying stiffness of the joints. If the truss, in which the members are interdependent, is loaded to its critical limit, then the entire truss must be in a condition of neutral equilibrium and the "r" versus load factor curves for the several joints will cross the line of "r" = 1.00 at the same critical load factor. However, the critical load factor for a group of members of the truss may be either above or below the true value determined from analysis of the entire frame.

Equilibrium Conditions. From the fundamental theory of stability of columns, it is known that if the centrally applied compressive force is less than the critical value, the column will remain straight. This straight condition of equilibrium indicates that the column is stable. With a slight increase in the compressive load above its critical value, the column will buckle.

To illustrate the equilibrium conditions, three cases of equilibrium of a ball are shown in FIGURE 3. It is evident that the ball on the concave spherical surface (a) is in a state of stable equilibrium, and that the ball on the convex spherical surface (c) is in a condition of unstable equilibrium, while, for the horizontal surface (b), the ball is in a state of neutral equilibrium. Considering the energy of the system, the previous conclusions can be made. In

FIG. 3. EQUILIBRIUM CONDITIONS

FIGURE 3 (a), any displacement of the ball will raise the center of gravity of the ball, which will require a certain amount of work that will increase the potential energy of the system. In FIGURE 3 (c), any displacement from the position of equilibrium will lower the center of gravity of the ball which will decrease the potential energy of the system. For the ball on the horizontal surface, a condition of neutral equilibrium, any displacement will not change the energy of the system. For the state of stable equilibrium, the energy of the system is a minimum, while, for the condition of unstable equilibrium, the energy of the system is a maximum. A column may be in a stable or unstable equilibrium condition depending on the value of the compressive load in relation to its critical value. The compressive load attains its critical value when the equilibrium condition changes from the stable to the unstable state.

Hoff applied the same principles of least energy, called "the Maupertuis' theorem," to the investigation of the stability of plane frameworks. He demonstrated that, if the framework is stable, the total potential energy of the entire framework is a minimum and that, by the Cross procedure, the values of the end moments corresponding to this minimum can be approximated by a sufficient number of steps of moment distribution, in each of which the total potential energy decreases. When $L/j < \pi$, the potential energy is a minimum and the equilibrium condition is stable. For a compression member with pinned ends and with $L/j > \pi$, the value of the total potential energy corresponds to a saddle point of the surface, with resulting unstable equilibrium.

Groups of Members. The use of groups of members of a frame for approximations in stability analysis has been indicated in the literature on stability research. The group receiving most attention for aeronautical frames consists of a compression member with its adjacent members having terminals, once removed, that are pin-ended. The assumption of pinned terminals results in conservative values for the critical load of the group. It is evident that judgment is required in selecting the members to form a group for approximation analysis. Tension members at the ends of a buckling member will increase the critical load. Adjacent compression members that are highly stressed and have pinned terminals will be of little value, if any, in resisting the buckling of the prime member under consideration. Pinned terminals at the adjacent members reduce their stiffness, while fixed terminals increase their stiffness. The greater the stiffness of the adjacent members, the greater the resistance offered to the buckling member. Members unstressed or having a reserve of buckling strength are satisfactory adjacent members in the sense of offering resistance to the buckling of the prime compression member.

In the included studies of the several typical trusses, the following groups of members and variations of same are indicated for analysis to ascertain the approximate critical load. (a) A buckling member, with adjacent members having terminals once removed, which is one joint from the end of the compression member. The adjacent members are to have terminals that are either pinned, fixed for compression members and pinned for tension members, all fixed, or fixed for compression members with the tension members omitted. A unit moment, to be applied at either end of the buckling member, will give the same "r." (b) A buckling member with adjacent members continued for terminals two joints from the end of the compression member. The terminals of the extended adjacent members are to be either all pinned or all fixed, with a variation in the pin-ended group of the omission of some of the compression members beyond one joint from the end of the buckling member. A unit moment is to be applied separately at each end of the prime buckling member. The "r" will not be the same for analysis at each end of the buckling member except where the critical load is indicated. (c) A joint having compression members, with terminals two joints removed, that are either all pinned, fixed for compression members and pin-ended for tension members, or all fixed, with a variation in the pin-ended group of the omission of some of the compression members beyond one joint removed from the selected joint. A unit moment is applied at the particular joint. The number of groups of members will accordingly depend on the number of buckling members, the number of joints having compression members, the variations due to terminal restraints, the omission of adjacent buckling members that reduce the critical load factor, and the omission of tension members where indicated. The approximations will be further affected by the design method for the structure, since airplane trusses are designed by ultimate load formulas while civil engineering trusses are designed by working

load formulas. At the design load, the former, which have slender compression members, have high L/j values, while the latter, with stocky compression members, have low L/j values. In airplane trusses, the compression and tension members may be of sections that are practically equal, while in civil engineering trusses the tension members are light compared to the stocky compression members. These differences in sections affect the stiffness ratios of the members at the joints and in turn the value of the critical load.

Approximate Estimate of Critical Load. Lundquist[2, 11] indicated a method of estimating the lowest critical buckling load for structural members by using the relations between the load on the structure and rotations of a joint after his equations for neutral stability[1, 2] have been tested for three assumed critical loads, each of which assumed loads is less than the lowest critical load on the basis of the axial load in each compression member being below that of its strength as a pin-ended strut.

The studies of several of the included civil engineering trusses, on basis of E_u, indicate that an estimate of the critical load may be approximated from the range in load factors referenced to the corresponding values of L/j between π and 2π for the prime compression member, which is the buckling member having the highest L/j at the critical load. When such range in load factors is within practical tolerances, the analysis for the critical load may be omitted. This approximation is not applicable to airplane trusses having slender members.

Effective Modulus of Elasticity. When a column is subject to stress above the proportional limit, the modulus values will in general become reduced. Therefore, the resistance of the section to bending deformation will not be measured by EI, as for the case where the stresses are below the proportional limit, but by $\bar{E}I$, where $\bar{E}$ is the effective modulus of elasticity for the section under the given stress distribution. Investigators have shown that the value of E depends on the intensities and distribution of the stresses, the corresponding values of the tangent modulus E_t, and the shape of the cross section. E_d, the double modulus, will always be between the values of E and E_t.

Borkman[12] suggests an expedient estimate of the effective modulus on the basis of a linear relation between the proportional limit and the yield point. Osgood[13] gives a summary of the origin of the double-modulus theory of column action and a brief of its mathematical basis.

The ultimate-load, short column design formulas in the Niles and Newell text[4] are used as a basis for a practical determination of the value of $\bar{E}$. This reduced modulus, E_u, is of a lower value than E_t and is intended to replace the Engesser and Karman formulas, which make no allowance for the effect of deviation of the practical column from the corresponding ideal column. This method of computing $\bar{E}$, which is backfigured from the empirical short column formulas, is a purely empirical engineering method of getting a value for practical use and, while it may not be justified from a theoretical consideration, it has been found that the practice gives reasonable results. For a low value of $\bar{E}$, the L/j is increased with a corresponding conservative critical load. This method is also given by the Army-Navy-Civil Committee on Aircraft Design Criteria.[14] They remark that the modified Euler formula does not have much practical importance in determining the short-column curve, but it is of practical interest in connection with the determination of the effective modulus which can be used to compute instability stresses. The value of this reduced modulus, E_u, at any given compressive stress is determined by solving the modified Euler equation after substituting the critical compressive unit stress and the corresponding slenderness ratio as obtained from the basic column formula. The equations express $E_u = E$ at one half the yield point, with a decrease in E_u to zero value at the yield point.

The assumption of computing $\bar{E}$ for tension stress on the same basis used for compression stress offers a convenient solution. An exception is made in this investigation to the assumption which requires $\bar{E} = 0$ when the tension stress is greater than the maximum allowed for a column of the same material. Since tension stresses in excess of yield point do not necessarily indicate failure, the value of $\bar{E}$ in tension members of structural carbon steel that are stressed above the yield point, under loading that is not critical for the compression members of the structural frame, is computed on the basis of the linear relation of a portion of the idealized stress-strain curve above the yield point.

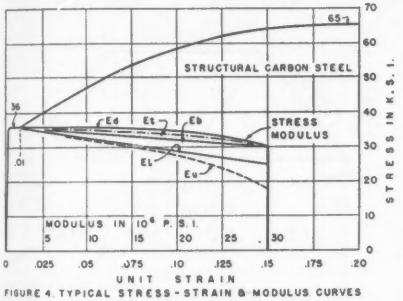


FIGURE 4. TYPICAL STRESS-STRAIN & MODULUS CURVES

The typical stress-strain and stress-modulus curves for structural carbon steel are shown in FIGURES 4 and 5.

Shanley[15, 16] concludes that the Engesser tangent modulus column formula gives the maximum load at which an initially straight, centrally loaded column remains straight, that this equation should be used as a basis for determining the buckling strength of members in the inelastic range, and that loading beyond the tangent modulus will produce permanent bending deformation. This recommendation for the tangent modulus verifies the prior conclusions by Templin, Hartman, Sturm, Holt, and Paul[17, 18] on the basis of tests of ideal columns of aluminum alloys, hot rolled steel of properties very close to structural carbon steel, magnesium alloys, and annealed steel sheet.

E_L is the author's suggested linear effective modulus, being a linear relation between 0.7 yield point and the yield point. This is a purely empirical relation for the purpose of simplification in computation of the effective modulus. It is intended to include an allowance for the deviation between the ideal and corresponding practical column and to give weight to the proportional limit stress above half the yield point. For metals other than structural steel, which may have a proportional limit below half the yield point, the suggested linear modulus is not intended to apply.*

Column Formulas. The relation between the Euler formula and the corresponding

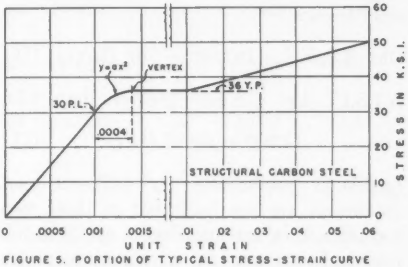


FIGURE 5. PORTION OF TYPICAL STRESS-STRAIN CURVE

values of L/j which depend on axial load follow. For a column with pinned ends:

$$P_c = \pi^2 EI/L^2, \text{ or } L = \pi\sqrt{EI/P}. \quad (10)$$

Substituting this value of L in the equation of $L/j = L\sqrt{P/EI}$, then for the theoretical pinned-end column

$$L/j = \pi. \quad (11)$$

For the restrained-end column,

$$P_c = c\pi^2 EI/L^2, \text{ and } L = \pi\sqrt{cEI/P} \quad (12)$$

and

$$L/j = \pi\sqrt{c} = \pi\sqrt{1/k^2} = \pi/k. \quad (13)$$

* Tabulated values of E_t, E_u, E_d, E_L, E_b and L/r modulus curves for structural carbon steel and reference to the evaluation of the effective modulus by investigators not mentioned herein are given in the dissertation.

For the theoretical fixed-end column, c = 4.0 and

$$L/j = 2\pi. \tag{14}$$

The ultimate load column formula for the airplane truss, with a yield point of 36,000 p.s.i. and E of 28,000,000 p.s.i., in terms of allowable design stress in p.s.i.,[14] is:

$$36{,}000 - \frac{1.172}{c}(L/r)^2. \tag{15}$$

For theoretical restrained ends, as commonly used in airplane frame design, c = 2.0.

Three working load column formulas, in terms of allowable working stress in design in p.s.i., are used for the structural carbon steel trusses:*

Old A.R.E.A.: $16{,}000 - 70\,(L/r)$; (16)

A.I.S.C., for L/r not greater than 120:

$$17{,}000 - 0.485\,(L/r)^2 \tag{17}$$

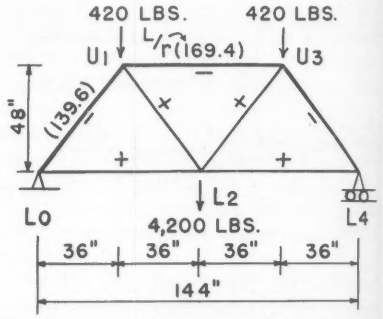
(although coefficients for different end conditions are not indicated in these two formulas, they are intended to apply to the practical column in construction); the 1943 A.R.E.A. formula for bridges, for L/r not greater than 140, and for riveted ends: $15{,}000 - (1/4)(L/r)^2$. (18)

Stability Analysis of Structural Frames

Airplane Truss (2 Studies). The truss, designed by ultimate load formulas, is taken from Niles and Newell[5] and is composed of carbon steel tubular section members having slenderness ratios in the long column range. The first study is based on E_u, which is the general practice in aircraft-frame analysis, and the second study on the basis of E. Since E_u at the design load factor 1.00 is close to E for all members of the truss, the second study is included to ascertain if the increase in critical load on basis of E is within a practical tolerance of the critical load on the modulus concept of E_u. E_u is calculated from:

$$\overline{E} = \frac{P}{A}\,\frac{[36{,}000 - (P/A)]}{1.172\pi^2}. \tag{19}$$

Study No. 1. Yield point at 36,000 p.s.i., proportional limit at 30,000 p.s.i., modulus concept is E_u, and E at 28,000,000 p.s.i. as commonly used for steel tubing. Basic data for the design load factor 1.00 is shown in FIGURE 6 and TABLE 1. Gross areas are used for computing the unit stress. $L/j = L\sqrt{P/\overline{E}I}$; C.O., the carry-over factor, and $SL/\overline{E}I$, the stiffness co-



AIRPLANE TRUSS - STUDY №1

FIG. 6. DESIGN LOAD FACTOR 1.00

efficient for respective values of L/j in axial compression or tension, are interpolated from tabular values; $\overline{E}I/L$ is computed; S, the stiffness of member, is the product of SL/EI by $\overline{E}I/L$; stiffness of joint is the sum of the stiffness of each member entering the joint. Since the L/j at the design load of all the truss members are above π but are less than 2π, the compression members would be unstable if they were pin connected. For joints L_0 and U_1 to have zero stiffness on the basis of stiffness coefficients for far ends fixed, the loading may be increased about seventeen per cent above the design load.

As the summation of the stiffness for all the members meeting at joints L_0, U_1

* Tabulated values for design stresses and the column curves are given in the dissertation.

and L_2 is positive for the design load, the stiffness criterion, which is a necessary condition for stability, is satisfied. However, this is not a complete proof that the truss is stable. A unit moment is applied separately at joints L_0 and U_1, and distributing this applied moment will indicate whether or not the unbalanced moment "r" is less than unity. To ascertain if "r" is unique and finite, the unit moment is distributed in a different order of balancing the joints to determine if essentially the same value of the unbalanced moment is obtained. If the "r" is less than unity, the series criterion for stability is satisfied, the series is convergent, and the truss is stable under the respective loading. The "r" curve is shown in FIGURE 7.

Analyses of groups of members of the airplane truss were made to determine if simple and satisfactory approximations to the critical stability may be obtained by analysis of small groups of the truss members and modifications of such groups rather than the truss as a whole. Six groups were considered: (1)—L_0 U_1 as the prime compression member with terminals once removed from its ends; (2)—same as for 1 except U_1 U_3 is the prime compression member; (3)—L_0 U_1 as the prime compression member with terminals twice removed from its ends; (4)—same as 3 except U_1 U_3 is the prime compression member; (5)—unit moment at L_0 with terminals twice removed; (6)—unit moment at U_1 with terminals twice removed. For (2), (3), and (4), the unit moment is applied separately at each end of the prime member. Compression members are either omitted or have fixed terminals in the fifth and sixth groups, where it is known from the basic data and analysis of prior groups that such members contribute to instability at low load factors. Tension members are omitted in some of

TABLE 1
AIRPLANE TRUSS-STUDY NO. 1—DESIGN LOAD FACTOR 1.00

Member	*Size inches*	*Stress pounds*	*Area sq. in.*	*Stress p.s.i.*	$\frac{Eu}{1{,}000}$	*Length inches*	*Mom. of inertia I*	$\frac{L}{j}$
L_0 U_1 U_3 L_4	$1\frac{1}{4} \times 0.035$	−3,150	0.1336	−23,577	25,321	60	0.02467	4.261
U_1 L_2 L_2 U_3	$1\frac{1}{4} \times 0.035$	+2,625	0.1336	+19,648	27,775	60	0.02467	3.714
U_1 U_3	$1\frac{1}{4} \times 0.049$	−3,465	0.1849	−18,740	27,963	72	0.03339	4.386
L_0 L_2 L_2 L_4	$1\frac{1}{4} \times 0.035$	+1,890	0.1336	+14,147	28,000	72	0.02467	3.766

Member	$\frac{L}{j}$	$\frac{SL}{EuI}$	$\frac{EuI}{L}$	S	Σs, L_0	Σs, U_1	Σs, L_2	*C. O.*
L_0 U_1 U_3 L_4	4.261	0.1518	10,411	1,580	1,580	1,580	—	5.607
U_1 L_2 L_2 U_3	3.714	1.3955	11,420	15,937	—	15,937	$\frac{15{,}937}{15{,}937}$	0.3012
U_1 U_3	4.386	0.0741	12,968	961	—	961	—	11.642
L_0 L_2 L_2 L_4	3.766	1.4048	9,594	13,478	13,478	—	$\frac{13{,}478}{13{,}478}$	0.2981
				Σ	15,058	18,478	58,830	—

Stress +: tension
−: compression

the groups to determine their effect on the value of the critical load.

Instability of a group of members of a truss does not necessarily indicate that the truss as a whole is unstable for the same loading. The critical load of groups of members will be either below or above or practically at the true critical load on the basis of the entire truss. The simplest group of members that will give a critical load in close approximation to the true value is desired. Results are discussed in the "Summary and Conclusion."

Study No. 2. Yield point, proportional limit, and basic design are the same as in Study No. 1, but the full value of E of

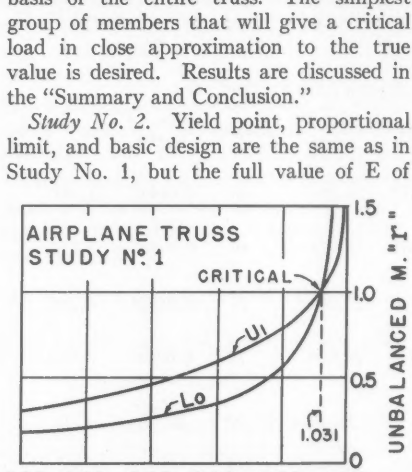


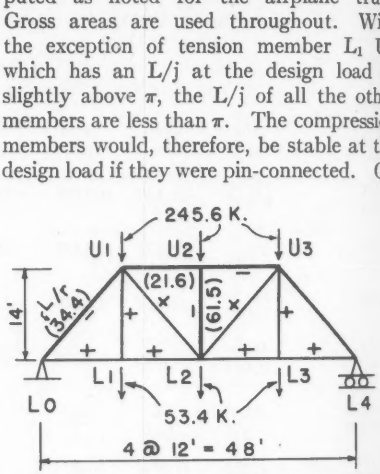
FIGURE 7

28,000,000 p.s.i. is used for all loadings. The critical load factor on the basis of E is 1.0464 and is 1.50 per cent above the value of 1.0310 on basis of E_u. It was found that for the tension members the reduction in L/j with the change from E_u to E is insignificant. Member $U_1 U_3$ is the prime compression member in the entire truss, although member $L_0 U_1$ has the highest compressive stress at the true critical load.

4 Panel Building Truss (9 Studies). This civil engineering truss of structural carbon steel, with compression members in the short column range, is designed by working load formulas. Design loading and E of 30,000,000 p.s.i. are the same for all the studies. Proportional limit, yield point, and E, are varied, as indicated. The first seven studies are of the Warren type truss, with the eighth and ninth studies modified for a Howe type truss.

Study No. 1. Yield point at 36,000 p.s.i., proportional limit at 30,000 p.s.i., modulus concept is E_u, and the Old A.R.E.A. design specifications. Truss diagram and loading are shown in FIGURE 8.*

The L/j, C.O., $SL/\overline{EI}$, and S, are computed as noted for the airplane truss. Gross areas are used throughout. With the exception of tension member $L_1 U_1$, which has an L/j at the design load of slightly above π, the L/j of all the other members are less than π. The compression members would, therefore, be stable at the design load if they were pin-connected. On



4 PANEL BLDG. TRUSS-STUDY Nº 1
FIG. 8. DESIGN LOAD FACTOR 1.00

basis of working load formulas, at the design load the numerical values of L/j are normally low for the compression members. Computed joint stiffness, on the basis of far end fixed, indicates positive values for all the joints up to the load factor 2.5640. A unit moment is applied separately at the joints which have compression members to determine the "r" for each loading increment. The prime compression member is $U_1 U_2$, which at the true critical load factor of 2.5553 has the highest L/j, highest compressive unit stress, and the lowest value of E_u.

Analyses of groups of members of the 4 panel building truss, Study No. 1, were made to determine if satisfactory approximations to the critical stability may be ob-

* Taken from a design by Professor E. J. Squire of the Polytechnic Institute of Brooklyn.

tained. Eleven groups, with a total of 39 combinations, were considered. These groups and combinations are an extension of those used for the airplane truss and follow the same pattern as shown and discussed for the 6 panel truss. Of particular note is that the approximate critical load factors from the stability analysis of truss member groups are within 0.5 per cent of the true value. The omission of tension members, which are generally of light section in civil engineering trusses, have no appreciable effect on the critical load factor. FIGURE 9 shows a portion of the "r" *vs.* Load Factor curve for analysis of the entire truss.

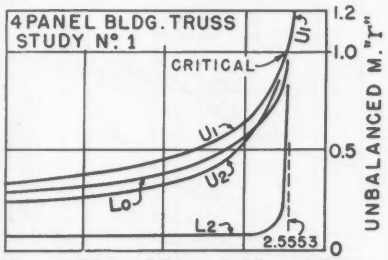


FIGURE 9

Studies No. 2, 3, and 4. In Study No. 2, the same design, proportional limit, and E_u are used as in Study No. 1, but the yield point is increased to 40,000 p.s.i. In Studies No. 3 and 4, the design is based on A.I.S.C. specifications, proportional limit at 30,000 p.s.i., and E_u. The yield point is 36,000 p.s.i. for Study No. 3 and 40,000 p.s.i. for Study No. 4. Positive stiffness for all the joints and L/j less than π for the compression members are indicated at the design load. The L/j and related values for Study No. 4 differ from those in Study No. 3 due to increase in the yield point.*

The prime compression member is U_1 U_2 in Studies No. 2 and 3 and L_0 U_1 in Study No. 4.

Studies No. 5, 6, and 7. These studies are based on E_t. In Study No. 5, design, proportional limit, and yield point are the same as for Study No. 1. Study No. 6 is based on the same design, proportional limit, and yield point as Study No. 3. Study No. 7 has the same design as Study No. 6, but the proportional limit is 27,000 p.s.i. and the yield point is 33,000 p.si., with the critical load factor determined from the analysis of two simple patterns of members of the truss of the first group as shown for the six panel truss.*

It is expected that the analysis of the group with fixed terminals will give a slightly higher critical load than the group with pinned terminals. The analysis indicates that either group gives practically the same critical load between the narrow limits of load factors 2.0270 and 2.0275. The prime compression member is U_1 U_2 in Study No. 5 and L_0 U_1 in Studies No. 6 and 7.

Studies No. 8 and 9. These studies for the Howe type truss are based on A.I.S.C. design specifications, E_u, and proportional limit of 30,000 p.s.i. Yield point is 36,000 p.s.i. for Study No. 8 and 40,000 p.s.i. for Study No. 9. The same truss dimensions and loading as shown for Studies No. 1 to 7 apply, except that member L_1 U_2 is parallel to member L_0 U_1. Tabulated values of "r" are given in the thesis. Member U_1 U_2 has the highest unit stress but L_0 U_1 has the highest L/j. With close to the same unit stresses in these two members, the higher L/j in L_0 U_1 is due mainly to its increased length. These two studies indicate that the member having the highest compressive unit stress may not have the critical L/j value.

Modulus Concept. The studies on the basis of E_t and on the basis of E_u indicate that the critical compressive unit stresses are practically at the yield point. Therefore, the studies were not extended to

* Tabulated values of "r" vs. Load Factor at joint L_0, U_1, and U_2 for loading above and below the critical load, on the basis of analysis of the entire truss for Studies No. 1, 2, 3, and 4, are given in the dissertation.

* Tabulated values of "r" vs. Load Factor for loading below and above the critical load are given in the dissertation.

determine the critical compressive unit stresses on the basis of E_d, E_b, or E_L. An illustration of the effect of several different concepts of the effective modulus of elasticity on the critical values for the same design in Studies No. 1 and 5 is shown in FIGURE 10. At the critical load factor 2.5553 in Study No. 1, E_u concept, the L/j in U_1 U_2, the prime compression member, is 4.108 and the unit stress is 35,681 p.s.i. or about 300 p.s.i. below the yield point. For the same design, but with the modulus concepts of E_t and E_d, the critical load factor is close to 2.58, with the unit stress in U_1 U_2 practically at the yield point.

6 Panel Highway Truss (2 Studies). This civil engineering truss of structural carbon steel, with the highly stressed compression members in the short column range, is designed by the 1943 A.R.E.A. working load formulas. Design loading, specifications, and E of 30,000,000 p.s.i. are the same for both studies. Proportional limit, yield point, and E are varied as indicated. Member L_2 U_3 has a low design unit stress due to limiting value for L/r.

Study No. 1. Yield point at 36,000 p.s.i., proportional limit at 30,000 p.s.i., and modulus concept of E_u. At the design load the compression members would be stable if pin-connected. Computed joint stiffness, on the basis of far ends fixed, indicates positive values for all the joints up to and including the load factor 2.43 or in excess of the true critical load factor of 2.3983 for the entire truss. The prime compression member is U_1 U_2, which at the true critical load has the highest L/j and compressive unit stress and the lowest value of E_u in compression. Critical L/j is 3.707 in L_0 U_1 and 3.977 in U_1 U_2.

FIGURE 11 shows the truss diagram and loading and the all pinned-end and corresponding all fixed-end groups of members for approximation studies. The first to fourth groups include a compression member with terminals once removed from each end. The fifth to eighth groups include a compression member with terminals twice removed. The ninth to thirteenth groups have the terminals twice removed from the joint where the unit moment is applied. The approximate critical load factors obtained from analysis of all the groups considered are within a maximum variation of 2.50 per cent of the true critical load factor. An approximation within 1.0 per cent is noted for 12 of 26 patterns. One or two additional patterns under each group, for a total of 22 patterns not indicated on FIGURE 11, based on combinations

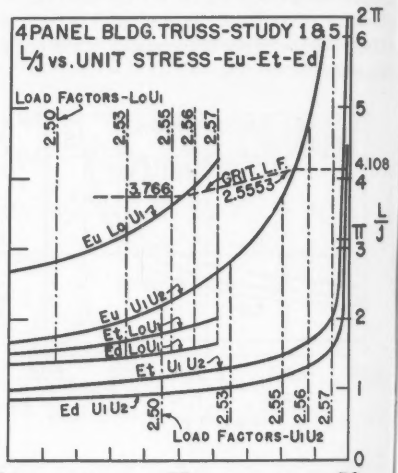


FIGURE 10

of fixed and pinned ends, omission of highly stressed compression members, and omission of some of the tension members, were also analyzed, with a resulting variation from the true critical load factor within 2.50 per cent. It was found that the omission of tension members has no appreciable effect on the critical load factor. The per cent variation from the true critical load for each group is marked on FIGURE 11.

Study No. 2. Same design as in Study No. 1, but the proportional limit is reduced to 27,000 p.s.i. and the yield point to 33,000 p.s.i. and the modulus concept is E_t. The critical load factor is determined from

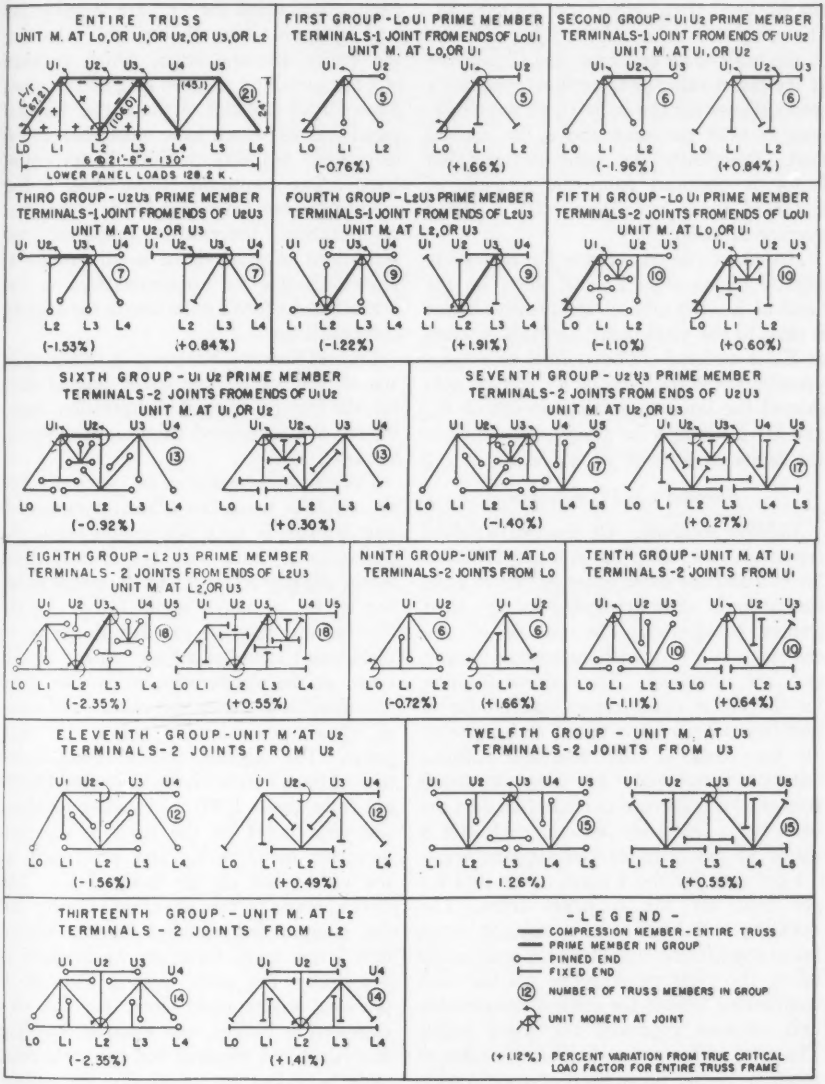


FIGURE 11 — 6 PANEL HIGHWAY TRUSS — GROUPS OF MEMBERS

the analysis of two patterns each of the second and sixth group on FIGURE 11. The computed values of the joint stiffness, on the basis of far end fixed, are all positive at the taken value of the critical load, with zero stiffness for the joint U_2 of least stiffness at 0.08 per cent above the critical load. Practically the same critical load factor is obtained from the analysis of either of the four groups, with a taken average of 2.2865.

Modulus Concepts. Since E_d values are slightly higher than E_t and since, on the basis of E_t, the critical compressive stress is close to the yield point, analysis on basis of E_d is omitted. The critical unit compressive stress on basis of E_L can be considered the same as on the concept of E_u, and for E_b it may be assumed as between the limits on basis of E_u and E_t.

Summary and Conclusion

Stability Analysis. Of the two stability criterions, the modified stiffness criterion $\Sigma S = 0$ and the series criterion "r" = 1.00, the latter is more applicable for the rigid frames considered. The values of the end restraints vary with increase in loading and are unknown. The critical loading for the entire truss frames and groups of members therefrom is found to be greater on the basis of the modified stiffness criterion than from "r." For the entire trusses, this difference in critical load on the basis of E_u for Study No. 1 in each case is about 17 per cent for the airplane truss, 0.4 per cent for the 4 panel truss, and 1.4 per cent for the 6 panel truss. The buckling members of the airplane truss fail at compressive unit stresses considerably below the yield point, while for the civil engineering trusses the critical compressive unit stresses approach the yield point. The total stiffness of each joint decreases in relation to the prevalence of compression members composing the joint and not in proportion to the increase in loading. The first joints to have negative stiffness along the loading range are those which lose their stiffness at the fastest rate. The operations involved in one complete moment distribution for "r" are lengthy for loading approaching the critical value for the entire airplane truss, which consists of a few members, and too long and burdensome for all loadings of the entire 4 and 6 panel trusses, which have more than a few members. Stability analysis of an entire truss frame containing more than a few members is not recommended as a practical computation procedure. Simplified assumptions of analysis of small groups of truss members for approximations to the critical load afford a reduction in the lengthy computations.

Critical Values—Trusses. A summary of the critical values and other related data for the highly stressed compression members of the considered trusses are shown in TABLE 2.

Critical Compressive Unit Stresses. For the airplane truss, the critical compressive unit stresses in both studies are below the proportional limit, with the critical stress factor slightly above 0.5 in the prime member $U_1 U_3$, although about 0.7 in $L_0 U_1$. No definite relation of critical stress to yield point is indicated for trusses of this type, as the slenderness ratios may have considerable variance and failure will occur at stresses considerably below the yield point. The highest critical compressive unit stresses for the civil engineering trusses are from about 1,500 p.s.i. below to about the yield point on the basis of the conservative modulus E_u and practically at the yield point on the basis of E_t. The critical stress factors are close to unity and the compression member having highest unit stress may, therefore, be stressed to practically the yield point. This is of practical importance, since, for the civil engineering trusses, the entailed stability analysis is not required and the yield point may be taken as practically the critical unit compressive stress. The highly stressed compression members of the civil engineering trusses are in the short column range, while for the airplane truss they are in the long column range.

TABLE 2
SUMMARY OF CRITICAL VALUES FOR TRUSSES

Truss name	*Study No.*	*Truss type*	*Design formula*	*Yield point p.s.i.*	$\overline{E}$	*Critical load factor*	L_0U_1						U_1U_2						$(U_1\ U_3)$					
							Stress p.s.i.	$\frac{\overline{E}}{1{,}000}$ *p.s.i.*	$\frac{L}{j}$	*Crit. stress factor*	*c.*	*k.*	*Stress p.s.i.*	$\frac{\overline{E}}{1{,}000}$ *p.s.i.*	$\frac{L}{j}$	*Crit. stress factor*	*c.*	*k.*	*Stress p.s.i.*	$\frac{\overline{E}}{1{,}000}$ *p.s.i.*	$\frac{L}{j}$	*Crit. stress factor*	*c.*	*k.*
Airplane	1	Warren	Ultimate	36,000	Eu	1.0310	24,307	24,567	4.392	0.675	1.955	0.715	19,320	27,856	4.462	0.537	2.017	0.704						
	2	Warren	Ultimate	36,000	E	1.0452	24,648	24,191	4.457	0.685	1.739	0.758	19,589	27,784	4.499	0.544	2.035	0.701						
4 Panel Bldg.	1	Warren	Old A.R.E.A.	36,000	Eu	2.5553	35,035	2,923	3.766	0.973	1.437	0.834	35,681	984	4.108	0.991	1.709	0.765						
	2	Warren	Old A.R.E.A.	40,000	Eu	2.8372	38,900	3,209	3.788	0.973	1.454	0.829	39,617	1,138	4.025	0.990	1.641	0.781						
	3	Warren	A.I.S.C.	36,000	Eu	2.1509	34,969	3,117	4.103	0.971	1.706	0.766	34,294	5,057	2.051	0.953	0.426	1.532						
	4	Warren	A.I.S.C.	40,000	Eu	2.3868	38,805	3,478	4.092	0.970	1.696	0.768	38,055	5,551	2.061	0.951	0.430	1.524						
	5	Warren	Old A.R.E.A.	36,000	Et	2.57791	35,343	9,920	2.054	0.982	0.427	1.530	35,998	556	5.489	1.00	3.052	0.572						
	6	Warren	A.I.S.C.	36,000	Et	2.21109	35,948	2,796	4.392	0.999	1.955	0.715	35,254	10,569	1.438	0.979	0.210	2.185						
	7	Warren	A.I.S.C.	33,000	Et	2.0272	32,960	2,509	4.460	0.998	2.015	0.704	32,321	10,085	1.410	0.979	0.201	2.228						
	8	Howe	A.I.S.C.	36,000	Eu	2.1344	34,701	3,897	3.655	0.964	1.354	0.860	35,072	2,814	2.954	0.974	0.884	1.064						
	9	Howe	A.I.S.C.	40,000	Eu	2.3680	38,499	4,334	3.651	0.962	1.351	0.861	38,911	3,178	2.928	0.973	0.869	1.073						
6 Panel Highway	1	Warren	A.R.E.A. (1943)	36,000	Eu	2.3983	32,209	10,554	3.707	0.895	1.394	0.847	34,536	4,372	3.977	0.959	1.618	0.786						
	2	Warren	A.R.E.A. (1943)	33,000	Et	2.2865	30,708	18,545	2.731	0.931	0.756	1.150	32,926	3,332	4.470	0.998	2.024	0.703						

Underlined values for member with highest L/j. $(U_1\ U_2)$—airplane truss.

Effective Modulus of Elasticity. For the airplane truss with critical values of E_u that are close to E, the elastic modulus E may be used, with an increase in critical load of 1.5 per cent. This indicates the possibility of simplification in stability calculations when the numerical values of E approximate E. Considering the studies for the civil engineering trusses, on the basis of modern design formulas, the critical E averages about 3.5 million p.s.i. and, for the old design formula, about 1.0 million p.s.i.

Yield Point Ratios. For both the same design formula and modulus concept, the theoretical critical load of the trusses are practically in the same proportion as the yield point ratios.

Critical L/j. The critical L/j values for the airplane truss are close to 4.493, which is for a compression member with one end restrained and the other end pinned or simply supported. For the civil engineering trusses of the Warren type, with E_u, the critical L/j is about 4.0. On the basis of E_t, with the exception of Study No. 5, the critical L/j for the civil engineering trusses is about the same as for the airplane truss with E_u. From Study No. 5, with E_t and the old design formula, the critical L/j is about 5.5. For the civil engineering truss of the Howe type, the critical L/j is about 3.7. Considering the modern design formulas for the civil engineering trusses of the Warren type, the indicated critical L/j is about 4.0 on the basis of E_u and about 4.46 on the modulus concept of E_t.

Prime Compression Members. The prime compression member is not necessarily the member having the highest compressive unit stress. It has the critical value of L/j and the pertinent value of the column end restraint coefficients. At the critical load, there may be compression members that, considered as a unit column, have not reached their full load. It may appear that the member having the highest L/j is the first to fail. When any member as part of a rigid frame becomes unstable, however, the entire structural frame, including all the tension as well as the compression members, lacks stability, as the interdependence of the members which constitute the rigid frame is lost.

Column End Restraint Coefficients. For both studies of the airplane truss, these values may be taken as practically equal to: $c = 2.0$ and $k = 0.7$. The first four studies of the 4 panel building truss and the first study of the 6 panel highway truss, of Warren type and with E_u, indicate the k value close to 0.78, with a corresponding c close to 1.65. This k value of 0.78 has been previously suggested for pin-end columns in civil engineering structures, instead of unity, to allow for the friction at the pin joints. Considering the 4 panel building truss of Howe Type, also with E_u, the c and k values are 1.35 and 0.86, respectively. For the studies with E_t, with exception of Study No. 5, the c and k values are about equal to 2.0 and 0.7 respectively, the same as for the airplane truss with E_u. The restraint coefficients indicated in Study No. 5, on the basis of the old design formula with low allowable unit stresses, are about 3.05 and 0.57 for c and k respectively. The restraint coefficients will vary with loading, but of interest in stability studies are the values at the critical load.

Approximate Estimate of Critical Load. The Lundquist method for approximating the critical load has been found applicable to the included trusses. As the critical compressive unit stresses in the civil engineering trusses are close to the yield point, the analytical methods of approximating the estimate of the critical load factor for such trusses may be omitted and instead be readily computed as practically equal to the ratio of the yield point to the highest compressive unit stress at the design load. If the prime compression member of the civil engineering trusses has a small range in load factors between conditions of $L/j = \pi$ and 2π, the critical load may be estimated within such range. The mentioned restraint coefficients for the prime compression member in the airplane and Warren

Type civil engineering trusses, on the basis of E_u, is a possible practical means of approximating the critical load of these types of trusses.

Groups of Members for Approximations. For the airplane truss, the approximations are limited practically to a group of truss members consisting of a compression member with the terminals twice removed from its ends or to a group with terminals twice removed from the joint of junction of greatest compressive unit stresses at which the unit moment is applied. The latter group has shorter computations for "r." For the 4 panel building truss, the simplest arrangement of a group of members may be used to approximate the critical load within 0.5 per cent of the true value. For the 6 panel highway truss, the simplest group pattern may be used for approximations within 2.0 per cent, and closer approximations result from analysis of a group consisting of a highly stressed compression member with terminals twice removed from its ends or of a group with terminals twice removed from a joint containing the highly stressed compression members and at which joint the moment is applied. The results of the stability analysis of groups of members of the three trusses show the possibilities of this simplified method of approximating the critical load and indicate the general arrangement of member groups that may be used.

Utility of Stability Analysis. Stability analysis has a practical value in the determination of the critical loading, from which the factor of safety of the structure may be obtained, for the airplane truss, which is designed by ultimate load formulas and has compression members in the long column range. For slender columns, instability occurs at unit stresses considerably below the yield point. The restraining effect of the tension members and the reserve strength compression members, which may offer buckling resistance, is unknown. For civil engineering trusses, designed by working load formulas, the critical compressive unit stress may be assumed as practically equal to the yield point, and the stability analysis may be considered futile and be omitted.

Concepts of the Effective Modulus of Elasticity. On the basis of the contained and available data on the several concepts of the effective modulus of elasticity and in the absence of theoretical or test data for this modulus for stresses in typical structural frames, the general deduction is made that the upper limit for this modulus may be the tangent modulus and the lower practical limit may be the modulus evaluated from the ultimate load short column formula. This deduction is premised on the recommendations for the tangent modulus resulting from laboratory tests on ideal columns and on the idea that, to allow for the difference between the ideal and the corresponding practical column, the effective modulus should be of a lower numerical value than the tangent modulus. In the absence of theoretical or test data for the determination of the effective modulus of elasticity for tensile stresses, the usual assumption is made of the same modulus values for equal stresses in either tension or compression. This assumption, on which there is some difference of opinion, is subject to the result of further research to obtain a more rational method of evaluating the effective modulus of elasticity for tensile stresses. The Linear Modulus by Borkman and the Linear Modulus suggested by the author are noted as simplified relations for estimating the effective modulus of elasticity.

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*SECTION OF ANTHROPOLOGY**

CRUCIAL PROBLEMS IN APPLYING ANTHROPOLOGY

By F. L. W. RICHARDSON, JR.†

Useful Concepts for Rough Appraisals—Time and Social Systems

Wrong Predictions. Anyone applying anthropology has assumed a serious burden. He presumes to be proficient in scientifically inducing changes that bring about desired ends. With a little experience in taking responsibility for action, however, he soon finds out whether the plans based upon his theories and hypotheses meet the test of action. If he is honest with himself, he soon realizes that his scientific training is frequently inadequate for the job at hand. The sad truth of the matter is that the theories, insights, and methods of anthropology provide an inadequate basis for scientifically applying anthropology to many human relations problems. Confronted with a wrong prediction, the applied anthropologist derives little satisfaction from the notion that other social and psychological* disciplines may be more limited.

Concentrating on Parts of Problems. Errors in predicting commonly arise from excessive preoccupation with a fraction of a total problem. Take, for example, clinical psychologists and psychiatrists who have assumed the responsibility for curing emotionally ill patients. Customarily, they undertake little systematic investigation of the patient's family as a social system and practically no investigation of the business or other systems in which he participates. If the main source of a patient's immediate emotional imbalance happens to lie not in his early family relationships but in repeated frustrations with business colleagues, should not the therapist explore systematically this latter problem rather than attack well-entrenched personal attitudes and value orientations?

* This paper was presented at the meeting of the Section, October 24, 1949. There were no meetings held in December of the Sections of Biology, Psychology, and Anthropology and the Division of Mycology.

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* Throughout the paper, psychological refers to psychology, psychiatry and psychoanalysis.

Again, take social engineers, whether social planners, scientists, or reformers, who fix up political and industrial organizations or attempt to improve whole regions and countries. It is not uncommon for these group "doctors" to overlook important parts of a problem. For example, successfully training new foremen to improve their handling of men has backfired when old-time, high-level, and "untrained" foremen later discredited the new practice as "soft." Not only had these latter and higher-placed foremen been overlooked, their habits were of too long standing to be easily changed.

In some undeveloped countries during the war, the introduction of farm machinery to increase food production actually resulted in food decreases as the machinery was diverted by power groups for production of more remunerative cash crops. Not only had the existence of these power groups been overlooked, so too had their long tradition of control for self-interest.

However much preoccupation with fractions of problems may result in inaccurate predictions, how does an applied scientist go about sizing up whole problems?

Viewing Whole Problems. Ideally to encompass a problem fully, it might be desirable to gather all current and historical facts on all individuals affected. But how can this be done practically? How is it possible to gather and analyze myriads of facts involving complex problems and large numbers of people? To show one way of simplifying this task, the writer will present briefly a rough method he has found useful.

The method is based on the concept of the social system.* Roughly speaking, the term "social system" connotes a group of people whose members, during periods of being together, are relatively isolated from nonmembers. As used in these pages, the term "social system" refers to interactions between persons who associate periodically. In small groups, interaction between members is customarily face to face, while in large groups members also are indirectly tied together by interaction through intermediaries.

This concept is by no means static or restricted to one point in time. Instead, it refers to the continuing and changing patterns of people's interactions as they become modified over time. As such, it has been valuable for formulating the following hypothesis: although not precisely understood, it appears that, the more frequently the members within a social system interact, (a) the more uniform their beliefs, attitudes, and behaviour become and (b) the more resistant they become to change. The usefulness of this hypothesis stems from the fact that the members of each social system whether family, church, or nation, ordinarily asssociate sufficiently with one another to acquire similarities in mannerisms, attitudes and other kinds of behaviour. In short, members of a particular social system usually have their own constellation of behavior, attitudes, and symbols. Therefore, in making a rough approximate appraisal of a situation, the members of a particular social system can frequently be considered as a unit on the assumption, for example, that most members will often manifest a similar response to a given stimulus.

Before taking up the discussion of the resettlement project, the writer would like to point out briefly and suggestively the interdependence between social systems and the behaviour and attitudes of members. Consider for a moment the fact that departments of social and psychological disciplines tend to narrow their student's attitudes and views of human relations to conform to that of the system. Then consider that over time these constellations of belief change, a circumstance disturbing to some and not to others. Finally, consider the competition between different social systems for the loyalty, services, and attitudes of given persons who play roles in each. Take, for example, men whose wives frequently urge them to spend more time with their families, whose bosses urge them to greater productive achievements, and whose political bosses occasionally demand long hours from them.

* HENDERSON, L. J. General Sociology—A Physiologists Interpretation by V. Pareto. Harvard University Press. Cambridge, Mass. 1935.

So it is with churches, clubs, groups of friends, and any number of other miscellaneous individuals and social groups. In varying degrees, all expect their members to voice "good" attitudes (*i.e.*, the brand of attitudes approved by the system in question).

Amid these rival social planets, little ego tries wending his own individual way. Year in and year out, treading his path between members of social systems, he carries away from each encounter a personal emotional response, and if during such times he is too sensitive to the least force exerted, he oscillates in and out of one social system after another. Some such people take to drink, others to crime, and still others are merely labeled weak or shiftless. Conversely, from the beginning, others resist the attraction of all systems excepting their families and their job or work group, and even here they are consistent in allocating more time to participate with colleagues and less with wife and children. Colleagues often consider such people "good workers" or "serious minded," while their families may refer to them as "poor fathers" or "narrow minded."

Thus, to understand why particular persons, to say nothing of groups, behave and feel as they do, the applied anthropologist should *first* be able to give a rough approximate appraisal of a person's or group's total relationships, *i.e.*, all those who have had an important influence both in the past and present. To do this, some method is needed that simplifies the characterizing of large numbers of people. The method here suggested for this *first stage* of analysis involves: (1) considering people as members of social systems and treating these social systems as units; and (2) considering the historical trends of these social systems.

To gather and analyze such facts, an applied anthropologist must become familiar with all competing social systems into whose orbit the people concerned either have moved or attempted to move or from whose orbit they have been ejected. Rarely, however, does he or any other social or psychological scientist have this knowledge, although each type of social system has, in varying degrees, been described and analyzed by members of one discipline or another. Such specialization may be convenient for academic study by traditional departments, but the applied human scientist who so restricts himself may in many cases find himself elaborating minor parts of total problems.

The Component Parts of Problems. In this first stage, of sizing up human situations roughly, the writer usually lists all types of social systems in order to force him to consider systematically all component parts of a total problem.

For convenience, he divides social systems into three main types—individual systems, institutional systems, and what might be called "areal systems." The relations between one individual and all his associates has been conceived as an individual system. Institutional systems include the following six types: (1) families; (2) cliques; (3) economic systems; (4) political systems; (5) religious systems; and (6) clubs and miscellaneous associations. The areal systems are nothing more nor less than combinations of individual and institutional systems. For convenience, they can be arranged in some such sequence as the following: (1) neighborhoods, tribes, and communities; (2) centers, *i.e.*, villages, towns, and cities; (3) center-suburb systems—including types of settlement ranging from a village with outlying farms to a metropolis with satellite suburbs; (4) counties, states, and regions; (5) nations and international systems.

In the remainder of the paper, we will be concerned with one institutional system, the clique, and one areal system, center-suburbs. These two systems have been chosen for discussion because they are perhaps less discussed than many others and because, in the resettlement project to be mentioned, they played a vital part.

The Case of a Resettlement Project

Failure of one Plan. The example in question is a resettlement project in a

mined-out coal area. The writer was intimately connected with this project for about two years, 1939–41, and has visited it several times since. It will not be the purpose of this paper to discuss the project in any detail, as it has, in part, been reported elsewhere.*

The project consisted of about fifty coal miners or so-called "homesteaders," and their families, who beginning in 1937 had moved into this newly opened community called Penncraft. Most of the homesteaders had come from surrounding small mining communities, many of them company-owned. Such a community was locally called a "patch," sometimes a "coal patch" or "company patch," and many of them were run-down communities with closely packed dilapidated shacks; in fact, rural slums. The resettlement project was started by members of a charitable organization who formed a corporation of five or six men who hired a field staff of three. The members of both the corporation and field staff are here referred to as management.

As first conceived, the purpose of the project was to experiment with methods to help coal miners weather depressions more successfully by learning new trades and practising subsistence agriculture. In the course of time, this desire was reformulated to express what became the ultimate goal, namely, to help the homesteaders help themselves to build a relatively self-sufficient community. With the aim of contributing to this main community goal, there were a number of community sub-goals, such as economic and recreational self-sufficiency, homesteader-built housing, and community self-government.

Management succeeded in organizing the homesteaders to build their own houses. Also, they succeeded in launching a sweater factory that employed women and girls and in running a cooperative store. They made little progress, however, in getting the homesteaders to participate in community organizations for such purposes as self-government and recreation.

As documented in part I of the report mentioned previously, participation in community organizations was desultory in 1939 and 1940. This was still true during a week's visit nine years later in September, 1949. Typical comments were, "We don't like goin' to meetings with all that formal stuff," or "to hell with wastin' time down there."

From conversation with the homesteaders, it soon became apparent that they had little experience in community organization, but exactly how they spent their time in the company patches prior to moving remained somewhat a mystery. It was felt that some further clues to their disinterest in community organizations might be forthcoming if a study was made of a typical coal patch. Such a study, it was hoped, would not only show why homesteaders failed to participate in community activities but might possibly suggest what measures could be taken to get them to support actively their own would-be self-governing community organization. At about the same time, a study of the local area, undertaken for a different purpose, accidentally provided the writer with further understanding.

The study of the coal patch was reported in part III of the previously mentioned report and the area study partly in part II, with the remainder reserved for part IV, yet to be published. Points from each, pertinent for this paper, will be briefly summarized here.

One Unappraised Part—the Center-Suburb System. One of the most obvious reasons why homesteaders failed to attend self-governing meetings, community dances, and the like was that their ties lay elsewhere, either with friends at the patch from which they had come or in the beer halls, movie theatres, and other amusement places in the three neighboring towns and cities. There was a town of 2,000 two miles away, and cities of 10,000 and 20,000 four and twelve miles away, respectively.

Even as regards shopping, the home-

* Richardson, F. L. W., Jr. Community Resettlement in a Depressed Coal Region. J. App. Anth. I Human Problems. 1 (1): 24–53; II Economic Problems. 1 (3): 32–61; III Problem of Community Change. 7 (4): 1–27.

steaders kept patronizing the company stores at their former patch or at the mine where the husband worked. This, plus the supermarkets in the neighboring cities, provided severe competition for the community cooperative store. As regards schooling, all children left the community, the older ones attending the high schools in the city of 10,000 four miles away. There, in the last few years, night football games with uniformed bands and thousands attending have been an increasingly significant feature. Competition for the band is keen, with even the grade-school girls twirling batons, hoping that someday they will become strutting majorettes. With boys on the squad and team, and both boys and girls in the band, the attention of parents and children alike is centered on the city for the Saturday night games. Recently, to add more excitement, one of the Penncraft boys was a backfield star and, as a result, received a scholarship to go to a university in the big regional center, a city of over a million, less than 50 miles away.

It should be stressed that miners and their families usually drive to town in their own cars; they do not rely primarily on bus service. Anomalous as it may seem, these sometimes impoverished workers, whether employed or unemployed, require cars for commuting to work. The more the coal in the area is mined out, the more the need for cars to drive to work or to new mines, some of which are 20 miles distant. Naturally, the miners often do move closer to their new place of work, but this is not always easy. Housing is scarce, because the coal companies no longer are building company towns. In fact, they are going out of this business and selling the patches they already own. Thus, cars become a necessity for husbands and fathers and, naturally, a convenience for wives and children.

Management obviously recognized the attraction of these town and city centers, but why did they underestimate the strength of their gravitational pull? Management strongly held the belief that Penncraft, with its fifty families, could develop its own gravitational force sufficient to resist the pull of these neighboring urban centers with populations numbering thousands. From the start, management introduced various organizational activities to do just this. In addition to the house building activity, the cooperative store, and the self-governing activities already mentioned, there were three economic enterprises designed to help make the community self-contained—hand-loom weaving, a sweater factory, and a farm. Few were interested in learning weaving, however, while the jobs in the sweater factory were mainly for women and girls, and, although the farm provided milk and produce, it gave steady employment to only one man.

The answer to why management tried to counteract the pull of the cities became apparent only after a study of the area had been completed. In looking into the recent *historical* changes, it was found that the farm villages of a generation ago had largely disappeared. These villages had been real centers for the surrounding farm families who actively patronized the churches, schools, and country store. Now, in contrast, the new farm generation has been increasingly oriented toward the urban centers. Although this shift was obvious, the writer did not grasp the full implications of it until he realized that most members of the project management had grown up in an environment similar to this earlier one, and had a strong emotional attachment to it. They felt that the coal miners, nursed in the "spending-spree" values of the modern urban system, lacked the essential "values" associated with this village system, such as individual initiative and community cooperation. Thus, they sensed that these essential "values" could be inculcated by recreating this past environment. The fact that it might be difficult was no deterrent in light of the great existing need as they saw it. In fact, to attempt doing it in other fashion was too great a fundamental challenge for most members of management to take seriously.

In retrospect, it is embarrassing to make

so much of the obvious point that people in suburbs look to their city center and that, unless transportation is lacking or better employment is provided elsewhere, they almost certainly will continue to do so. This point was not obvious to management, however, and an understanding of management's position (vital for every applied scientist) was not meaningful to the writer until (1) the recent historical competition between village and city centers had become clearly established, and (2) the appropriate loyalties, values, and behaviour of both management and homesteaders had become properly associated with one of the systems—those of the homesteaders with the urban system and those of management with the village system. The writer feels that, if he had originally conceived of the center-suburb relationship as a social system, he might have grasped the significance of these facts more quickly.

A Second Unappraised Part—the Clique System. The attraction of the city might in large part explain why homesteaders were drawn away from participating in various community organizations, but it by no means explains the lack of all participation. The town visits of homesteaders were not that frequent. Obviously, there were other factors of a more subtle nature at work, and we set out to explore some of these when we undertook the study of the neighboring coal patch.

For our purposes, the study of the coal patch, with its 146 families, confirmed the suspicions that community organizations were inactive in local patches. In this particular patch, only two community organizations were truly active, both church groups. The surprising discovery to the writer, however, was that functioning kin groups were rare due to population turnover. By and large, the only frequent community contacts between immediate families living in the community was with next-door neighbors, who shouted back and forth from their porches.

Friendship based on propinquity was widespread. In the other words, a system of clique relations existed based primarily on location. However, these locational cliques were by no means mutually exclusive. Individuals sometimes belonged to more than one, with the result that cliques were more or less interlocking, running up one street and down another. Thus, in the competition to attract members, the gravitational pull of cliques was the dominant force, with the apparent exception of the two church groups just mentioned.

Here again, an examination of historical developments disclosed highly significant facts. Actually, the membership of the two successful community organizations was composed of interlocking cliques or groups of neighbors on particular streets or sections thereof, and this had been true from the start. In contrast, some of the unsuccessful community organizations were composed of individuals belonging to widely separated cliques—a situation analogous to Penncraft. In Penncraft, however, cliques barely existed in the first years, because individual homesteader families had been selected with no particular regard for groups of friends and because of management's policy, for example, of discouraging the gathering of "idle" groups.

Based on these current and recent historical observations, the hypothesis is suggested that, at least in communities of this area where functioning kin groups are rare, clique organization is a necessary first stage in the formation of community organizations. If this is true, then one good reason the Penncraft homesteaders failed to support their own self-governing community organizations was that their friendship groups or clique systems were embryonic. In other words, the seeds from which community organizations grow had not yet been sown. To quote from part III, page 22, of the reference mentioned previously:

"Apparently the confidence and informal teamwork gained among a handful of close friends must necessarily precede any effective large-scale organization. Accordingly, cliques form the core of all formal organization and historically speaking they repre-

sent the first stage in the evolution of all non-family groups. In short cliques are the initial aggregates around which larger groups can later crystallize.

Unfortunately we know all too little about the intricacies of group behaviour, but the experience we do have demonstrates the fact that people must emotionally accept one another before the habit of cooperation becomes easy—and this emotional acceptance commonly takes place in the informal clique stage.

The remarkable success of the Jewish resettlement communities in Palestine is in no small measure due to a systematic development from closely knit cliques. In Penncraft, had this process been fully realized, we believe the evolution toward effective community organization would have been more direct, more rapid, and more substantial."

Summary and Conclusion

The Concept of the Social System. The job of applied anthropology is to bring about the social changes necessary to achieve a desired end. The crucial problem in this combined art and science is the ability to make reliable predictions—a none too common skill. That predictions fail is perhaps more frequently due to excluding important variables from consideration than from wrongly estimating the variables considered. The reason a particular applied social and psychological scientist excludes important variables from consideration is largely that these variables have not been included in the teachings of his discipline. By so restricting themselves, these "scientists" are acting as *bona fide* members of their own professional social system, with its particular constellation of cosmology, symbols, and beliefs.

In making a rough first appraisal of all the important variables in a total situation, the concept of the social system is an extremely useful abstraction, adding a little more uniformity to our understanding of nature. Many of the otherwise bewildering number of individuals, with their innumerable beliefs, behaviors, and symbols, become partially understood as constellations in one or more social systems.

Unfortunately, anthropology has not exploited this concept as fully as the applied anthropologist could hope. By and large, the "pure" anthropologists have concentrated on describing social systems from the family on one end of the scale to the small local community on the other. To be more useful in applying anthropology, however, the scale must be extended on both ends—on one to include an individual and his personal system and on the other to include regions and nations.

From the discussion of the resettlement project, it was disclosed that a wrong prediction resulted from failure to consider competition from two social systems. On one end of the scale, the clique system had been ignored; on the other, the center-suburb system had been underestimated. The latter, however well known, had to the writer's knowledge never heretofore been explicitly conceived and described as a social system. In short, these two systems, lying on or beyond the periphery of conventional anthropology, proved to be crucial in the solution of this particular community problem.

Time and social systems. Supposing that the writer had been satisfied to explain that the community organizations in the resettlement project had failed because people preferred to remain in their cliques—what then? What could management or homesteaders do with such information? How could they progress from predominantly clique organizations to more inclusive community organizations? Management more or less subconsciously held the belief that cliques are undesirable and not to be encouraged. By studying recent historical changes in a mining town, however, it was discovered that successful community organizations evolved apparently out of cliques. Two or more coalescing cliques supplied the seeds from which these successful community organizations had apparently grown. Thus, the hypothesis was proposed that, in

these mining towns, cliques are a necessary first stage in the evolution of community organizations. If this is true, then the steps that lead to eventual community organization should be: (1) encouraging rather than discouraging cliques; and (2) somehow bringing about a coalescence of cliques, so that they can become the nuclei from which community organizations can later evolve.

Similarly, the evolution of the center-suburb system was presented, in which were pointed out the growth from village to city center and the associated change in beliefs, values, and behaviour of members. The significance of these facts to the project was stressed, for management shared the values associated with village centers and the miners shared the values of city centers.

This concludes an outline of some first steps the writer has found useful in applying anthropology to the solution of the human problems with which his clients have been faced. Sometimes, a solution based on this rough first appraisal has appeared sufficient and, in fact, has later been verified by the only real test of a prediction—the test of action. At other times, in more complex situations, it has been necessary to take a second step by proceeding further with more precision to understand the inner functioning of institutional systems and the individual systems of particular persons. This second step has not been examined in this paper. If these rough appraisals or first steps are skillfully executed, however, the required course of action may become so obvious that a second step is superfluous. In short, the point of this paper is that, in sizing up human problems, first steps come first.

REPORT OF THE ANNUAL MEETING

December 7, 1949

The 132nd Annual Meeting of the Academy, for the election of Officers and Fellows, the presentation of reports, and the transaction of other business was held at the Hotel Astor on the evening of Wednesday, December 7, 1949.

The first order of business was devoted to the reports of the Officers and Committees of the Academy.

REPORTS OF OFFICERS AND COMMITTEES

Report of the Recording Secretary. The unprecedented developments of the past year clearly demonstrate that the activities of the Academy, including the Conferences, Sectional Meetings, Membership expansion, and publication program are not only acquiring a considerable momentum, but are the basic factors for achieving our goal with maximum success.

The recognition of the importance of our work by Mr. and Mrs. Norman B. Woolworth has provided the Academy with a home of its own for the first time in more than a century. Through the generous gift of their mansion, an opportunity is presented for the Academy to make a noteworthy stride forward by creating a hospitable gathering place for its Members with adequate accommodations for meetings and administrative activities.

The Recording Secretary is pleased to state that the progress reported last year has continued, although unusual efforts have been required in the conduct of the Building and Sustaining Fund Drive so that the problem of housing the Academy might be solved.

Through the efficient efforts of the Chairmen of the Sections and Conferences, 44 stated Sectional meetings and eight conferences were held during the past 11 months, at which 262 important scientific papers were presented and discussed. Thanks and appreciation are hereby extended to the Chairmen and speakers for the undoubted success of these meetings and the high quality of the papers presented.

The wide range of the subjects dealt with is indicated in the following list of Conferences held:

"The Ground Substance of the Mesenchyme and Hyaluronidase," Chairman, F. Duran-Reynals, Yale University, New Haven, Connecticut.

"The Place of Statistical Methods in Biological and Chemical Experimentation," Chairman, Edwin J. deBeer, The Wellcome Research Laboratories, Tuckahoe, New York.

"Development and Uses of Antimetabolites,"

Chairman, D. Wayne Woolley, The Rockefeller Institute for Medical Research, New York, New York.

"Coccidiosis," Chairman, Sterling Brackett, Stamford Laboratories, American Cyanamid Company, Stamford, Connecticut.

"Specific Methods of Analysis," Chairman, Samuel E. Q. Ashley, General Electric Company, Pittsfield, Massachusetts.

"International Conference on Vitamin E," Chairman, Karl E. Mason, University of Rochester School of Medicine and Dentistry, Rochester, New York.

"The Chemotherapy of Tuberculosis—The Experimental Approach," Chairman, Geoffrey W. Rake, The Squibb Institute for Medical Research, New Brunswick, New Jersey.

"Mechanism and Evaluation of Antiseptics," Chairman, Herbert L. Davis, Ethicon Suture Laboratories, Johnson & Johnson, New Brunswick, New Jersey.

During the past year 949 new Members were added to our rolls, as follows: 2 Benefactors, 7 Honorary Life Members, 27 Active Life Members, 44 Sustaining Members, 830 Annual Active Members and 39 Student Members. One Active and one Life Member became Patrons and 203 Annual Members were transferred to Life Membership by payment of the Life Membership Fee. Thirteen transfers and 24 reinstatements were effected in the Annual Classes.

The Academy has lost by death 3 Active Life Members, 2 Sustaining Members and 19 Annual Active Members. One hundred nineteen resignations were accepted, 3 names were dropped for nonpayment of dues and 5 for not having qualified for membership.

The record now stands with a net gain of 822 Members. There are, at present, upon the rolls of the Academy 4,852 Members, of whom 609 are Fellows, classified as follows: 3 Benefactors; 3 Patrons; 52 Honorary Life Members; 331 Active Life Members; 167 Annual Sustaining Members; 4,180 Annual Active Members; 116 Annual Student Members.

Report of the Corresponding Secretary. The Corresponding Secretary reported that no changes had occurred in the Honorary Life Membership Class. As of October 31, 1949, 52 Honorary Life Members were enrolled in this Class, which, with the election of seven new members at this Annual Meeting, brings the total to 59 Honorary Life Members.

Report of the Editor. Since the date of the last Annual Meeting, December 15, 1948, The New York Academy of Sciences has issued 9 ANNALS monographs, comprising a total of 1,682 pages. Included in these are 173 papers by 283 authors. The TRANSACTIONS (286 pages) brings the total pagination to 1,968.

The list of publications is as follows:

ANNALS

Volume 50, Article 5, *Thyroid Function As Disclosed by Newer Methods of Study* (12 papers), by J. H. Means *et al.* Pages 279–503. Published January 27, 1949.

Volume 51, Article 3, *Ocean Surface Waves* (15 papers), by B. Haurwitz *et al.* Pages 343–572. Published May 13, 1949.

Volume 51, Article 4, *Molecular Interaction* (17 papers), by R. M. Fuoss *et al.* Pages 573–852. Published May 31, 1949.

Volume 51, Article 5, *Antibiotics Derived from* Bacillus polymyxa (18 papers), by P. H. Long *et al.* Pages 853–1000. Published June 22, 1949.

Volume 50, Article 6, *The Adrenal Cortex* (14 papers), by R. Gaunt *et al.* Pages 509–678. Published June 27, 1949.

Volume 52, Article 1, *The Relation of the Adrenal Cortex to the Structure and Phagocytic Activity of the Macrophagic System* (1 paper), by A. S. Gordon and G. F. Katsh. Pages 1–30. Published July 27, 1949.

Volume 52, Article 2, *Drainage Evolution in the Appalachians of Pennsylvania* (1 paper) by Henry D. Thompson. Pages 31–62. Published August 12, 1949.

Volume 52, Article 3, *Vitamin E* (67 papers), by K. E. Mason *et al.* Pages 63–428. Published October 31, 1949.

Volume 52, Article 4, *Coccidiosis* (28 papers), by S. Brackett *et al.* Pages 429–624. Published November 10, 1949.

In addition to the articles published during the year, the following are now in press and will be published during the next three months:

Volume 50, Article 7, *Allergy* (10 papers), by A. F. Coca *et al.*

Volume 50, Article 8, *Structure in Relation to Cellular Function* (13 papers), by Robert Chambers *et al.*

Volume 52, Article 5, *The Chemotherapy of Tuberculosis—The Experimental Approach* (20 papers), by Geoffrey Rake *et al.*

Volume 52, Article 6, *The Place of Statistical Methods in Biological and Chemical Experimentation* (16 papers), by E. J. de Beer *et al.*

TRANSACTIONS

Series II, Volume 11, Numbers 1–8, consisting of 286 pages, was completed, printed, and distributed each month from November, 1948, to June, 1949, inclusive.

During the period December 1, 1948–October 31, 1949, the Academy has distributed 65,842 separate publications and 11,109 complete volumes of the various published series, as follows:

Annals	*Separate Numbers*	*Volumes*
Gratis: Members	11,789	
Gratis: Authors, reviews, exchanges and donors	6,831	667
Sales	7,495	65
Authors Reprints	25,600	
Memoirs		
Sales		1
Special Publications, Volumes I–IV		
Gratis: Authors, reviews		16
Sales		391
Scientific Survey of Porto Rico		
Gratis	51	
Sales	175	
Transactions, Series II		
Gratis: Members, authors, exchanges, reviews	6,198	4,377
Sales	252	92
Authors Reprints	7,075	
Bulletins		
Gratis: Members, Affiliated Societies' Members, reviews and gratis	376	5,500
	65,842	11,109

The Academy has received from exchange institutions 6,926 separate publications, which have been duly turned over to the Library of The American Museum of Natural History, in accordance with the purchase agreement between the two institutions. All publications included in the Annals and Trans-

actions, as soon as they are ready for distribution, are sent to the exchange institutions throughout the world.

The total sales value of publications distributed gratis to the Members, authors, donors, reviewers, and exchange institutions is $41,865.49.

Report of the Treasurer. The past year has been highlighted by some of the most substantial contributions in the history of the Academy. By means of these, there has been opened up for the Academy a vista of unprecedented development and growth as an organization of service in its fields of endeavor.

The most outstanding contribution is that of Mr. and Mrs. Norman B. Woolworth. Their gift of 2 East 63rd Street, Manhattan, has given the Academy a permanent home. To implement this gift, and to establish it in operation for the Academy, the Academy's position has been strengthened by gifts of Members through their own Building and Sustaining Fund Drive. Thus, Members and well-wishers in this fiscal year have advanced the Building and Sustaining Fund Drive by contributions of $80,134.22.

Another important gift is that of $10,000 from Mr. A. Cressy Morrison by which he has established The A. Cressy Morrison Prize Fund, the income of which will make possible, in perpetuity, not less than two annual awards of his well-known Prizes in Natural Science.

We gratefully acknowledge with sincere appreciation the donations and grants-in-aid totaling $32,831 toward the costs of the publication program and general expenses during the years 1949 and 1950, as follows: Abbott Laboratories, Inc. $750; American Cyanamid Company $400; Bristol-Myers Company $500; Burroughs-Wellcome Company $1,353; Chas. M. Cox Company $100; Colgate-Palmolive-Peet, Inc. $200; Distillation Products, Inc. $900; Dome Chemicals Company $75; Dow Chemical Corporation $500; E. I. duPont de Nemours & Co., Inc. $300; Freshman Vitamin Company $25; Chas. E. Frosst & Company $250; Hess & Clarke $200; Hexagon Laboratories, Inc. $200; Heyden Chemical Corporation $250; Hoffmann-LaRoche, Inc. $1,400; Hynson, Westcott & Dunning $100; Lambert Pharmacal Company $100; Lederle Laboratories Division, Amer. Cyan. Co. $3,278; Lever Bros., Inc. $250; Eli Lilly & Company $900; McNeil Laboratories $50; The Mennen Company $50; Merck & Company $4,900; Miscellaneous contributions $450; Monsanto Chemical Corporation $400; Nutrilite Products, Inc. $100; Panray Corporation $200; Park & Pollard Company $100; Parke Davis & Company $300; S. B. Penick & Company $100; Chas. Pfizer & Company $3,650; Raymond Laboratories $50; Rexall Drug Company $500; Roche-Organon, Inc. $150; Doctor Salsbury Laboratories $200; R. P. Scheer Co. (Gelatin Products Division) $500; Schenley Industries, Inc. $400; Schering Corporation $250; G. D. Searle & Company $100; R. B. Semler, Inc. $50; Sharp & Dohme, Inc. $1,350; E. R. Squibb & Sons $1,200; Sterling-Winthrop Research Institute $650; Testagar & Co., Inc. $100; The Toni Company $200; The Upjohn Company $1,300; U. S. Vitamin Corporation $200; VCA Laboratories $500; Vitaminerals, Inc. $100; Whitmoyer Laboratories, Inc. $200; Woods Hole Oceanographic Institution $1,500; Wyeth, Inc. $1,000.

The income from annual dues and sales of publications totaled $71,472.00. The Academy's property, including its building, equipment, investments and cash on hand now amounts to $622,780.28 gross.

The expenses show a deficit of $1,803.67. This amount covers an excess of operating expenses of $282.98, plus deductions totaling $1,520.69 for losses through sales of investments. However, this is offset with a sum of $26,501.05 credited as a reserve for 1950, of which $18,746.05 is for grants-in-aid for publications and $7,755 reserved for operating expenses, representing one-sixth of the income from 1949 Annual dues.

The fiscal year was changed to begin as of November 1st each year and to end the following October 31st. During the past year, the books of accounting have been established on an accrual basis instead of a cash basis, as heretofore. This work has been especially facilitated by the addition to the Administrative Staff of Mr. Eugene Doerr, as Accountant.

This comprehensive review of our financial position, favorable as it is, should not be taken as indicating that the Academy is now affluent and, therefore, in no need of additional contributions toward its goal. Nothing could be further from the truth. The fundamental facts are that the acquisition of the new building has entailed greater responsibilities and immediate problems to be faced, involving alterations for its use as a public building as required by the City of New York, as well as expenses of moving, equipment, and maintenance for our activities. The Academy also has undertaken the liability of a $200,000 first mortgage on the property with payments to be made on annual interest and amortization. Nevertheless, with the continued and generous support of the Members and friends of the Academy, combined with the aid of the loyal and hardworking Members of the Council and the Academy's staff, our progress toward success should be assured.

A summary of the auditor's report is presented here which outlines the Academy's financial affairs during the fiscal period ending October 31, 1949. In this instance, it represents a period of eleven months, due to the advancement of the opening date of the fiscal year.

By order of the Council, the books of account have been checked and certified by a professional firm of auditors. The property of the Academy has been verified by the auditors and the Finance Committee. This report has been approved by the Finance Committee as of December 1, 1949, as provided in the Bylaws.

Report of the Fund Drive Advisory Committee. The Advisory Committee on the Building and Sustaining Fund campaign considers this a fitting time to present a report to the Members on the progress of the Fund Drive.

After a slow start, the Drive acquired momentum during this year so that now we can state the receipt of contributions and pledges, as of October 31, 1949, amounted to $80,134.22. This includes $68,134.22 resulting from the contributions of 586 Members, including Life Membership and Patron fees; $11,000 from the American Cyanamid Company; $9,544.31, transfer of the William Otis Sweet Fund as Mr. Sweet's contribution to the Building Fund; and, $1,000 from the Granthale Foundation.

THE NEW YORK ACADEMY OF SCIENCES

Balance Sheet

October 31, 1949

	Total	*General Fund*	*Grants-in-Aid Fund*	*Endowment Funds*	*Morrison Prize Fund*	*Bldg. & Sustaining Fund*
ASSETS						
Cash in Chase National Bank	$24,030.95	$441.41	$13,296.90	–	$262.50	$10,030.14
Accounts receivable—publications	3,009.33	3,009.33	–	–	–	–
Membership dues receivable	2,003.50	2,003.50	–	–	–	–
Investments	95,496.69	416.25	–	$45,535.95	7,284.38	42,260.11
Real estate—2 East 63rd Street	425,035.00	–	–	–	–	425,035.00
Office furn. & equipment at cost	6,513.49	5,804.57	–	–	–	708.92
Building fund pledges receivable	20,342.67	–	–	–	–	20,342.67
Prepaid expenses	356.85	114.01	–	–	–	242.84
Interfund loans receivable	45,991.80	268.11	5,586.42	40,000.00	–	137.27
Total Assets	$622,780.28	$12,057.18	$18,883.32	$85,535.95	$7,546.88	$498,756.95
LIABILITIES						
Accounts payable	$7,710.47	$7,710.47	–	–		–
Deferred income—dues	7,755.00	7,755.00	–	–		–
Mortgage payable	200,000.00	–	–	–		$200,000.00
Interfund loans payable	45,991.80	5,586.42	$137.27	$268.11		40,000.00
Total Liabilities	$261,457.27	$21,051.89	$137.27	$268.11		$240,000.00
RESERVES						
For delinquent dues	$1,346.00	1,346.00	–			
For unexpended grants	18,746.05	–	$18,746.05			
Total Reserves	$20,092.05	$1,346.00	$18,746.05			
CAPITAL						
Capital Funds	$341,230.96	($10,340.71)	–	$85,267.84	$7,546.88	$258,756.95
Total	$622,780.28	$12,057.18	$18,883.32	$85,535.95	$7,546.88	$498,756.95

THE NEW YORK ACADEMY OF SCIENCES

Statement of Income and Expense

From December 1, 1948 to October 31, 1949

	Total	*General Income Account*	*Grants-in-Aid*	*Endowment Funds*	*Morrison Prize Fund*	*Bldg. & Sustaining Fund*
Income						
Annual Membership dues	$39,816.75	$39,816.75	–	–	–	–
Sale of Academy publications	23,900.25	23,900.25	–	–	–	–
Contributions & grants-in-aid	333,344.45	416.25	$32,831.00	$393.82	$7,284.38	$292,419.00
Dinner subscriptions	1,307.75	1,307.75	–	–	–	–
Library exchange, Amer. Mus. Nat. Hist.	100.00	100.00	–	–	–	–
Investment income	4,750.98	2,962.36	–	215.49	262.50	1,310.63
Interest on bank funds	26.12	–	–	–	–	26.12
Total Income	$403,246.30	$68,503.36	$32,831.00	$609.31	$7,546.88	$293,755.75
Expenses						
Publication costs	$48,401.17	$37,520.17	$10,881.00	–		–
General administrative expense	26,126.16	26,126.16	–	–		–
Meetings & Conferences	7,743.96	4,540.01	3,203.95	–		–
Prizes	800.00	600.00	–	$200.00		–
Building Fund Drive expenses	6,395.03	–	–	–		$6,395.03
Total Expenses	$89,466.32	$68,786.34	$14,084.95	$200.00	–	$6,395.03
Unexpended balance	$313,779.98	($282.98)	$18,746.05	$409.31	$7,546.88	$287,360.72
Less: Loss on stock sales	1,520.69	1,520.69	–	–	–	–
Total Income over Expenses	$312,259.29	($1,803.67)	$18,746.05	$409.31	$7,546.88	$287,360.72
Allocated to Capital Funds	$293,513.24	($1,803.67)	–	$409.31	$7,546.88	$287,360.72
Balance to Reserve	18,746.05		$18,746.05			
Total (as above)	$312,259.29					

The Academy's position was most substantially improved by the gift of Mr. and Mrs. Norman B. Woolworth of their home. Through their generosity, the Academy has now come into possession of a building, adding a net contribution from Mr. and Mrs. Woolworth of $225,000.

We are thankful to these benefactors, the Members, and the friends of the Academy for this progress so necessary for the development of the Academy's potentialities.

While we take pride in our growing possessions, the completion of our project is a matter of necessity. We need to build up our Sustaining Fund that we may broaden the scope of our activities and carry on our publication program successfully. Although our building is in excellent condition, nevertheless certain alterations must be made as prescribed by the City of New York. Adequate furnishings and equipment are sorely needed and the responsibility of the mortgage must be carried until it is finally amortized.

This is a program which becomes the second phase of the Drive and is in itself an important and arduous task.

Its completion will require additional supporters and further contributions, as well as volunteers to aid us in extending this part of the Drive. We are just as dependent upon the gifts and generosity of our many Members and friends as heretofore.

If we continue in a spirit of determination, with belief in our future and our high ideals, this Committee will look forward to reporting upon a still greater measure of success at our next Annual Meeting.

AWARDS OF PRIZES

Two prizes of $200 each in The A. Cressy Morrison Prize Competition in Natural Science were offered for the year 1949.

Twelve papers were presented, all of high quality. After careful consideration and consultation with experts in the fields represented, the Committee makes the following awards:

(1) A prize of $200 to the paper entitled "Stability Studies of Structural Frames," by Abraham Slavin, Consulting Engineer, Department of Civil Engineering, Polytechnic Institute, Brooklyn, New York.

(2) A prize of $200 to the paper entitled "Embryology of the Viviparous Insects," by Harold R. Hagan, 63 Adrian Avenue, New York, New York.

(3) Honorable mention to the paper entitled "Comparative Biology of Salticid Spiders at Rancho Grande, Venezuela. Part IV. An Analysis of Display," by Jocelyn Crane, Research Zoologist, Department of Tropical Research, New York Zoological Society, New York, New York.

The Committee is pleased to announce that Mr. Morrison, in establishing The A. Cressy Morrison Prize Fund, has made it possible to devote its income to the annual renewal of his offer of two prizes of $200 each, for the two most outstanding papers in a field of natural science covered by the Academy and its Affiliated Societies. Therefore, on behalf of Mr. Morrison, these two prizes will be offered for competition during the year 1950. Announcement of these awards will be made at the Annual Meeting of the Academy to be held in December, 1950.

ELECTION OF FELLOWS AND HONORARY LIFE MEMBERS

The following Members were elected to Fellowship:

Anthony A. Albanese, Ph.D.
Henry Aldrich, Ph.D.
William Antopol, M.D.
Joseph W. Beard, M.D.
James H. Birnie, Ph.D.
Morton S. Biskind, M.D.
Ilsley Boone, B.S.
John R. Bowman, Ph.D.
Sterling Brackett, Ph.D.
Joseph H. Bunim, M.D.
Abraham Cantarow, M.D.
Harold G. Cassidy, Ph.D.
I. L. Chaikoff, M.D.
Clarence C. Clark, Ph.D.
Beverly L. Clarke, Ph.D.
Amando Clemente, Ph.D.
Amador Cobas, Ph.D.
Seymour Stanley Cohen, Ph.D
W. M. Copenhaver, Ph.D.
Ivor Cornman, Ph.D.
Theodore J. Curphey, M.D.
Herbert L. Davis, Ph.D.
Irene Corey Diller, Ph.D.
Richard Donovick, Ph.D.
Thomas F. Dougherty, Ph.D
Victor A. Drill, M.D.
Francesco Duran-Reynals, M.D.
William R. Duryee, Ph.D.
Philip Eisman, Ph.D.
Herbert Elftman, Ph.D.
Conrad A. Elvehjem, Ph.D.
Gladys A. Emerson, Ph.D.
Earl W. Flosdorf, Ph.D.
Jay T. Fox, Ph.D.
John P. Fox, Ph.D.
Mario Gaudino, M.D.
Arnold Gesell, Ph.D.
Morris Greenberg, M.D.
I. C. Gunsalus, Ph.D.
Florence A. Heisler, Ph.D.
Percy L. Julian, D.Sc.
Berwind P. Kaufmann, Ph.D.
John G. Kidd, M.D.
Hadley Kirkman, Ph.D.
Benjamin Kramer, M.D.
Charles A. Kraus, D.Sc.
Martin Kuna, M.S.
Max A. Lauffer, Jr., Ph.D.
Robert F. Light, M.S.
Milton Levy, Ph.D.
S. E. Luria, M.D.
Ross A. McFarland, Ph.D.
Karl E. Mason, Ph.D.
James E. Miller, M.D.

George S. Mirick, M.D.
Philip McC. Morse, D.Sc.
John S. Nicholas, Ph.D.
Clara Nigg, Ph.D.
Alex B. Novikoff, Ph.D.
I. A. Parfentjev, Ph.D.
Arthur K. Parpart, Ph.D.
Karl E. Paschkis, M.D.
Ernest Peter Pick, M.D.
Abou D. Pollack, M.D.
Eric Ponder, M.D.
Keith R. Porter, Ph.D.
Robert W. Ramsey, Ph.D.
Cornelius P. Rhoads, M.D.
J. M. Ruegsegger, M.D.
Bela Schick, M.D.
Leon H. Schneyer, Ph.D.
Malvina Schweizer, Ph.D.
Stuart L. Seaton, B.S.
Beatrice Carrier Seegal, M.D.
A. M. Shanes, Ph.D.
Charles A. Slanetz, Ph.D.
Philip A. Stansly, Ph.D.
Abraham Stone, M.D.
Marion B. Sulzberger, M.D.
Wilbur W. Swingle, Ph.D.
John T. Tate, D.Sc.
Hugh S. Taylor, D.Sc.
Kenneth Wade Thompson, M.D.
William S. Tillett, D.Sc.
John W. Tukey, Ph.D.
Wayne W. Umbreit, Ph.D.
Victor Vacquier, M.A.
Emery Imre Valko, Ph.D.
Erwin P. Vollmer, Ph.D.
Matthew Walzer, M.D.
Alan T. Waterman, Ph.D.
Addison Webb, B.A.
Alfred J. Weil, Ph.D.
William F. Wenner, Ph.D.
Abraham White, Ph.D.
Alexander S. Wiener, M.D.
James W. Wilson, Ph.D.
Ernest Witebsky, M.D.
Emil Witschi, Ph.D.
Stewart G. Wolf, Jr., M.D.
Robert B. Woodward, Ph.D.
John Lamar Worzel, Ph.D.
Irving Wright, M.D.

Honorary Life Membership was conferred upon the following eminent scientists:

Sir Thomas Dalling, Animal Diseases, Chief Investigator, Animal Disease Research Association, The Animal Health Trust, London, England.
Sir David Kennedy Henderson, Psychology, Professor of Psychiatry, University of Edinburgh, Edinburgh, Scotland.
Albert Jan Kluyver, Microbiology, Professor of Microbiology, Technical University, Delft, The Netherlands.
Kaj Ulrick Linderstrom-Lang, Chemistry, Director, Carlsberg Laboratory, Copenhagen, Denmark.
Jean Piaget, Psychology, Professor of General Psychology, Lausanne University, Lausanne, Switzerland.
Carl-Gustaf Arvid Rossby, Meteorology, Professor of Meteorology, University of Chicago; Director, Högskolas Institut für Meteorologi, Stockholm, Sweden.
Felix Andries Vening-Meinesz, Hydrology, Professor of Geodosy and Geophysics, University of Utrecht, The Netherlands.

ELECTION OF OFFICERS

The following officers were elected for the year 1950:

President

M. L. CROSSLEY

Vice-Presidents

GEORGE B. PEGRAM
ROSS A. BAKER

Chairmen of Sections

GEORGE G. ADAMS
E. D. GOLDSMITH
THOMAS N. JENKINS
JUNIUS B. BIRD
LEO SHEDLOVSKY
HANS PANOFSKY

Chairman of Division

FREDERICK REISS

Recording Secretary

HARRY A. CHARIPPER

Corresponding Secretary

RALPH H. CHENEY

Treasurer

ROBERT F. LIGHT

Editor

ROY WALDO MINER

Councilors (1950–1952)

E. H. NORTHEY
JOHN A. AESCHLIMANN
ERICH M. SCHLAIKJER

Finance Committee

ADDISON WEBB, *Chairman*
GORDON Y. BILLARD
HARDEN F. TAYLOR

PROGRAM OF THE EVENING

After the Business Meeting, following program was given:

Colloids of the Atmosphere and Laboratory Monodisperse Colloids. By Victor K. LaMer, Department of Chemistry, Columbia University.

The Production of Snow and Rain in Cloudy Skies. By Vincent J. Schaefer, General Electric Company, Schenectady, New York.*

* Abstracts of these papers have not been received.

STABILITY STUDIES OF STRUCTURAL FRAMES

By ABRAHAM SLAVIN

Awarded an A. Cressy Morrison Prize, 1949

[An abrigment of this paper was presented at a meeting of the Section of Physics and Chemistry of The Academy. As the abridgment appears in this issue (pp. 82–98), the abstract is omitted here.]

EMBRYOLOGY OF THE VIVIPAROUS INSECTS

By HAROLD R. HAGAN*

Awarded an A. Cressy Morrison Prize, 1949

A monograph giving for the first time a summary of the historical and embryogenic details of all viviparous insects published to date. Many others are treated historically. New contributions by the author are included: one new viviparous embryology (Diploptera) appears for the first time, another (Arixenia) is given less fully and a third (Glossina) has had further data added to its known embryonic history. Introductory chapters on terminology and general hexapod development together with the method of presentation should enable the beginner to follow the text while the detailed, thorough treatment will satisfy the professional entomoligist. So many orders possess viviparous species that the work will prove a valuable guide in the study of the development of most insects. Theoretical as well as factual considerations affecting the viviparous condition receive proper attention. There are 232 figures in the 160 illustrations and a comprehensive bibliography covers all pertinent literature on the subject.

Of the fifteen chapters in the text, three are devoted to the clarification of embryological terms and a general consideration of insect embryology to prepare the beginning student that he may grasp the morphological details to follow. These chapters also tend to render the volume suitable for a text as well as a reference work for the professional entomologist. Chapter four reviews the types of viviparity among insects and distributes the species among the four functional types discovered. These types and the species in them are assorted purely on physical and physiological interrelationships exhibited by the embryos, their mothers, or both. Chapters five to fourteen contain all the known viviparous embryogenies, and historical summaries of many whose viviparity has been erroneously cited or whose embryogenies remain to be studied. The last chapter brings together, in summary form, the several essential facts of viviparity and their possible bearing on embryonic development, the immature offspring, the mother and the species as a whole.

The viviparous condition seems to modify trophic, instinctive, morphological and psychic responses to insects, or to be possible as a result of such modifications. The author supports the second alternative. Viviparity is a relatively new condition in insects and seems to be replacing oviparity in several orders. It apparently reduces environmental resistance in species possessing it. To support the descriptive matter there are 232 inked drawings in 160 text figures.

* Department of Biology., College of the City of New York, New York, N. Y.

COMPARATIVE BIOLOGY OF SALTICID SPIDERS AT RANCHO GRANDE, VENEZUELA. PART IV. AN ANALYSIS OF DISPLAY

By JOCELYN CRANE*

Awarded Honorable Mention in the A. Cressy Morrison Prize Competition, 1949

A comparative analysis of courtship and threat displays in about fifteen species of neotropical jumping spiders resulted in the following major conclusions: first, a number of previously unrecognized elements, both internal and external, are important in the innate releasing mechanism; second, not only the form, but also the relative importance of the factors of the external stimulus configuration varies within the family; third, these variations appear often to be of phylogenetic significance.

* Department of Tropical Research, New York Zoological Society, New York, New York.

Throughout the family, vision is the dominant sense, as previous investigators have agreed. Nevertheless, in those genera which are held to be the more primitive, it appears that far greater dependence is placed on chemical senses than in more advanced forms. Contact chemical stimuli play minor parts in courtship throughout the family. Evidence is presented that, contrary to existing views, these spiders are sensitive also to airborne chemical stimuli which play an important secondary role with respect to vision. It appears that various salticid subfamilies tended to evolve through the same general pattern, from a high dependence on all chemical stimuli through a stage in which airborne chemical stimuli are of relatively greater importance, to complete visual domination, in which the chemical senses are relegated to an extremely subservient role.

Among the visual factors, motion, general form, and size take precedence over all secondary sexual "ornamentation," although the latter is, to human eyes, often the most conspicuous characteristic of the spider. In several exceptional instances, however, striking patterns were shown experimentally to have high releasing or directive value for certain stages of threat or courtship. Although the majority of conspicuous epigamic "decorations" did not appear to have a definite function in display, they are not, of course, necessarily nonadaptive characters in this field. Some doubtless merely present a typical example of the unequal value of elements in the contemporary configurational stimulus situation and of the absence of a lock-key releasing formula. The effective configuration is made up of many small bits, including both vestigial and recent elements. Together they have cumulative releasing, directive or merely excitatory value; but a number may be missing from an individual situation without noticeable effect, even when other elements are not reinforced.

It appears that in the most primitive forms, inter-male display does not exist; in the intermediate groups it is scarcely differentiated from courtship, arises from mistaken identity and frequently ends in true fighting; while in the most advanced forms inter-male display has been highly ritualized and is completely distinct from courtship. In these cases it perhaps has a stimulatory function similar to that which apparently occurs in certain birds. Releasing and directive factors in threat display appears to be altogether non-chemical.

Concepts of dominance, sociality, territoriality and displacement behavior seem to apply on a primitive level to certain salticids. No evidence was found, however, of display learning, imprinting or copying. Display motions probably evolved from a number of actions occurring in the ordinary life of the spider. It is suggested that among salticids display actions in general precede the associated morphological specializations, and that they probably play a secondary role in speciation.

NEW MEMBERS

Elected December 15, 1949

LIFE MEMBERSHIP

Fitzpatrick, Florence K., Ph.D., Rickettsiae, Viruses, Tuberculosis. Research Bacteriologist, Sharp and Dohme, Inc., Glenolden, Pa.

Grossman, Cecilia M., M.A., Biology, Education. Teacher of Biology, Far Rockaway High School, Far Rockaway, L. I., N. Y.

SUSTAINING MEMBERSHIP

Behrman, Samuel, M.S., Biology, Physics and Chemistry. Clinical Director, Ortho Research Foundation, Raritan, N. J.

Feldman, Samuel, M.D., Peripheral Vascular Disease. Associate, Peripheral Vascular Diseases; Chief, Peripheral Vascular Clinic, Beth El Hospital, Brooklyn, N. Y.

Jacoby, Kurt, Biochemistry, Chemistry, Biology. Secretary-Treasurer, Academic Press Inc., New York, N. Y.

Scherlis, Leonard, M.D., Cardiology, Internal Medicine. Resident in Cardiology, Mt. Sinai Hospital, New York, N. Y.

ACTIVE MEMBERSHIP

Aitken, Gerard J., Jr., M.D., Medicine. Fellow in Medicine, Queens General Hospital, Jamaica, L. I., N. Y.

Arena, Joseph A., Jr., M.D., Medicine. Fellow in Surgery, Alexander Blain Hospital, Detroit, Mich.

Bauer, Louis Hopewell, M.D., Medicine. Practicing Physician, Hempstead, L. I., N. Y.

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